Municipal and County Engineering

DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF ALL PUBLIC WORKS

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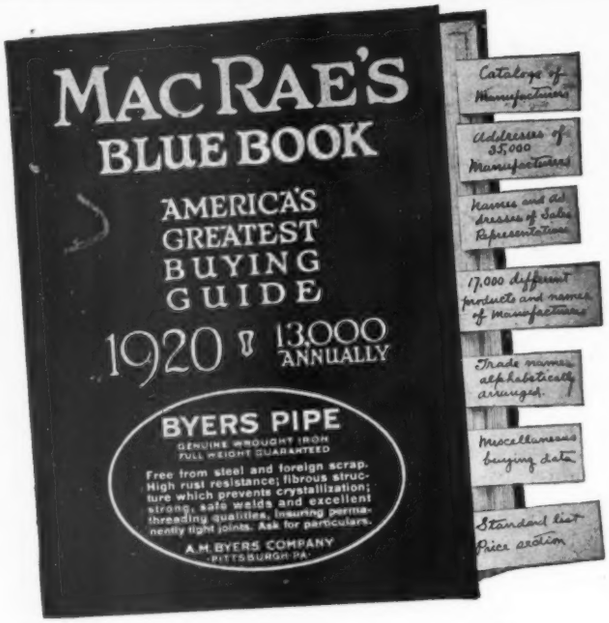
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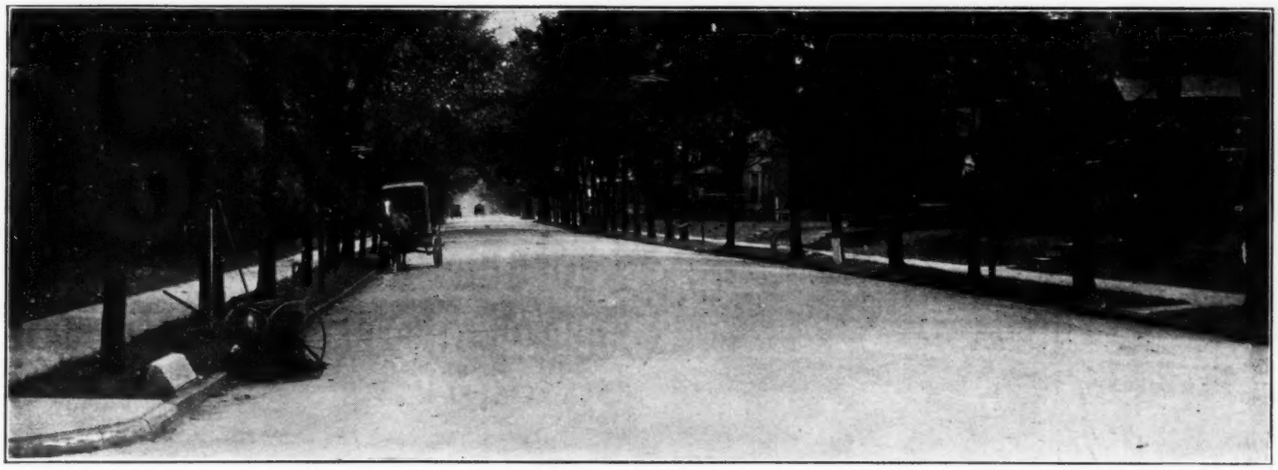

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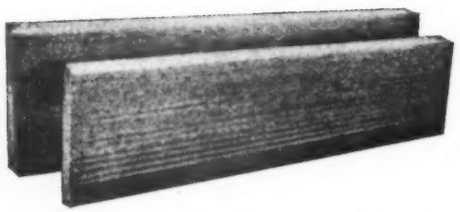

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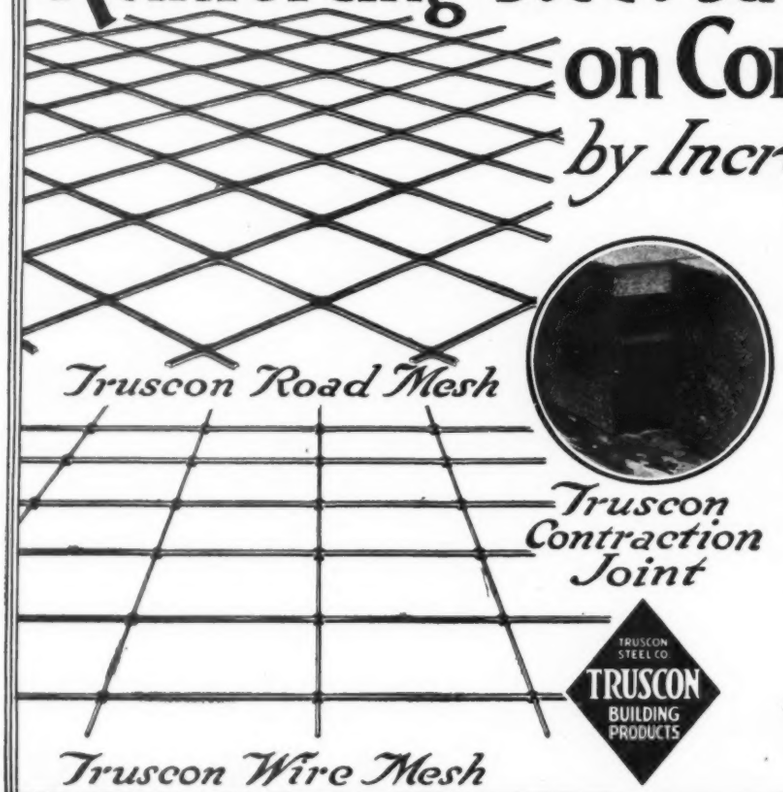

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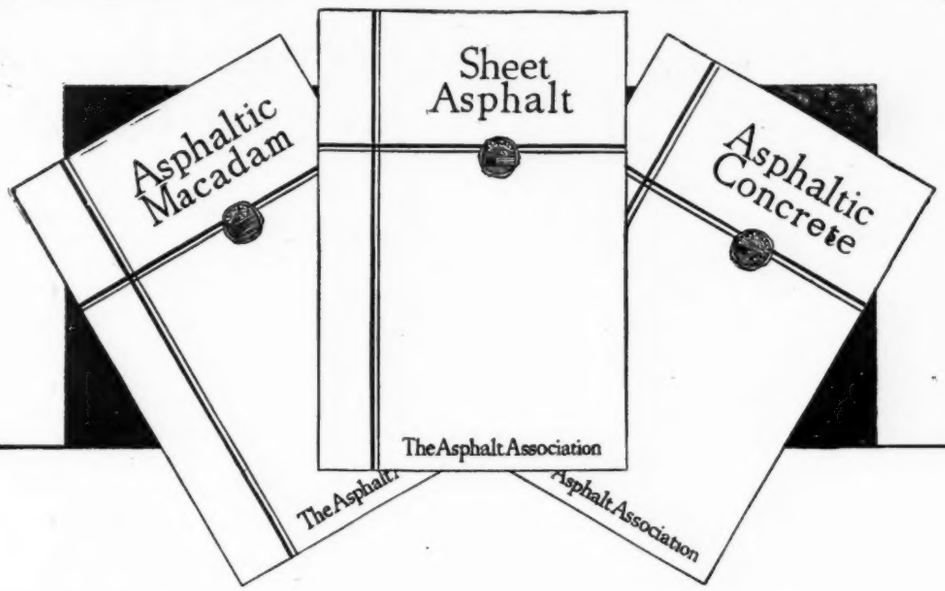

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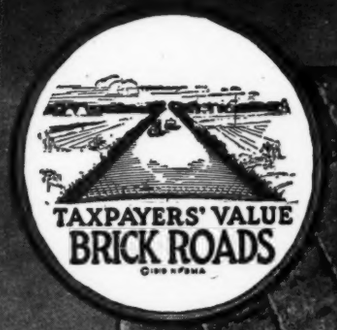

How old is this BRICK PAVEMENT?

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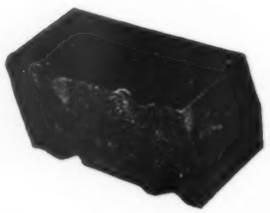

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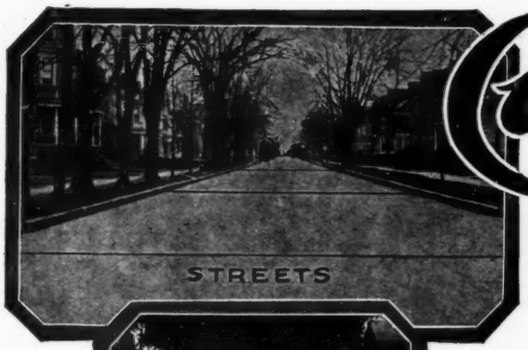

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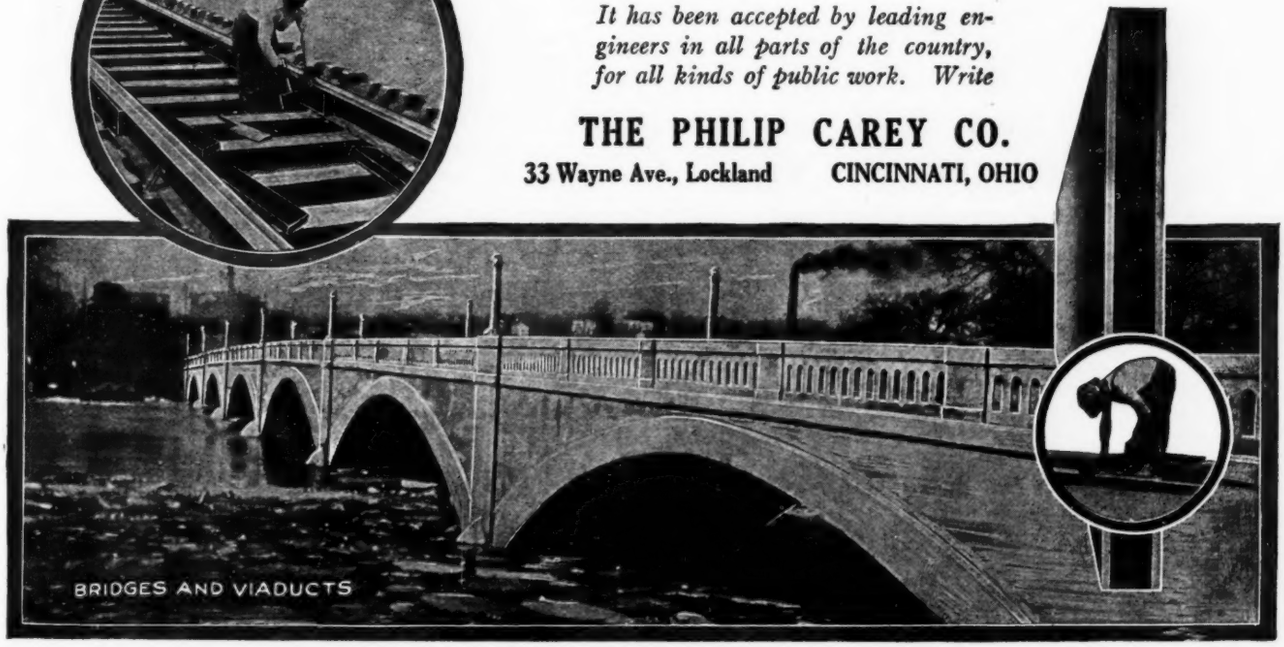

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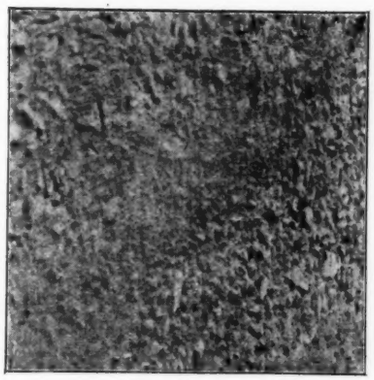


LOAD

Usually 6 inches thick

THE BASE

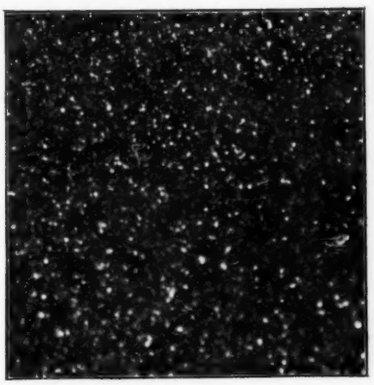
of a

Sheet

Asphalt

Pavement

May be of bituminous concrete or Portland cement concrete. The surface of the base should have a rough finish so that the binder will adhere firmly to it. The greatest function of the base is to distribute the *load*.



IMPACT

Usually 1½ ins. thick

THE BINDER

is an intermediate course between the base and the wearing surface. It is generally composed of an asphaltic concrete mixture—fine stone, sand, stone dust and asphaltic cement. The greatest function of the binder is to distribute *impact*.

WEAR

Usually 2 inches thick

WEARING SURFACE

is laid directly on the binder. It is composed of properly graded sand, stone dust and asphaltic cement. Sheet Asphalt wearing surface is durable, malleable, resilient. Its greatest function—which it does always—is to resist *wear*.

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Contractors' Tools and Machinery.
Austin-Western Co., Ltd., The
Barber Asphalt Paving Co.
Good Roads Machinery Co., Inc.
Littleford Bros.
Smith Co., T. L. The.

Contractors' Wagons.
Austin-Western Co., Ltd., The

Conveying Machinery.
Pawling & Harnischfeger.
Portable Machinery Co., Inc.

Cranes and Hoists.
F. C. Austin Co., Inc.
Heltzel Steel Form & Iron Co.
Pawling and Harnischfeger.

Creosote.
The Barrett Co.
Republic Creosoting Co.

Creosoted Wood Block.
(Factory Floors, Bridge Floors)
Republic Creosoting Co.

Crushers, Rock and Ore.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Crushed Stone.
Cleveland Stone Co., The
Ohio Quarries Co.

Culvert Molds.
Austin-Western Co., Ltd., The
Storms Mfg. Co.

Culvert Pipe, Cast Iron.
American Cast Iron Pipe Co.
Cast Iron Pipe Publicity Bureau
U. S. Cast Iron Pipe & Fdy. Co.

Culvert Pipe, Vitrified.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., Wm. E.

Culverts.
De Smet Quartz Tile Co.
Truscon Steel Co.

Curb and Gutter Forms.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Curb Bar.
Truscon Steel Co.

Curbing, Sandstone.
Cleveland Stone Co., The
Ohio Quarries Co.

Direct Oxidation Process.
Direct Oxidation Process Corp.

Drag-Line Excavators.
F. C. Austin Co., Inc.
Pawling and Harnischfeger.

Drag Scrapers.
Austin-Western Road Machinery Co.

Drain Tile.
Dee Clay Mfg. Co., W. E.

Dryers.
Cummer & Son Co., The F. D.

Dump Cars.
Austin-Western Road Machinery Co., The

Dump Wagons.
Austin-Western Road Machinery Co., The

Dust Laying Compound.
Barber Asphalt Paving Co.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.

Edge Protector.
Truscon Steel Co.

Elastite.
Philip Carey Co., The.

Electrical Wires & Cables.
American Steel & Wire Company

Elevating Graders.
Austin-Western Road Machinery Co.

Engineering Instruments.
Kolesch & Co.
Lufkin Rule Co., The

Excavating Machinery.
F. C. Austin Co., Inc.
Pawling and Harnischfeger.
Sauerman Bros.
Smith Co., T. L. The.

Expansion Joint Compound
The Barrett Co.
Philip Carey Co., The.
Truscon Steel Co.

Fillers (Paving Joint).
Barber Asphalt Paving Co.
The Barrett Co.
Philip Carey Co., The.
The Texas Co.

Fire Brick.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Flue Liners.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Forms, Sidewalks, Curb & Gutter.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms, Road.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms (Sewers & Conduits).
Heltzel Steel Form & Iron Co.

Forms (Wall Bldg., Construction, Etc.).
Heltzel Steel Form & Iron Co.

Gas Pipe.
American Cast Iron Pipe Co.
Cast Iron Pipe Publicity Bureau
Crane Co.
U. S. Cast Iron Pipe & Fdy. Co.

Graders.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Gravel Screener and Loader.
The Jordan & Steele Mfg. Co., Inc.
Good Roads Machinery Co., Inc.

Heaters (Rock and Sand).
Littleford Bros.

Heating Wagons (Oil and Tar).
Good Roads Machinery Co., Inc.
Littleford Bros.

Hoists (Concrete, Gasoline and Hand).
Pawling and Harnischfeger

Hoists, Electric.
Pawling and Harnischfeger.

Hoists, Steam.
Lewis-Hall Iron Works.

Hot Mixers.
F. C. Austin Co., Inc.
Barber Asphalt Paving Co.

Hydrants.
Flower Valve Mfg. Co.

Inlets (Sewer).
Dee Co., Wm. E.
Madison Foundry Co.

Insulating Material.
The Barrett Co.

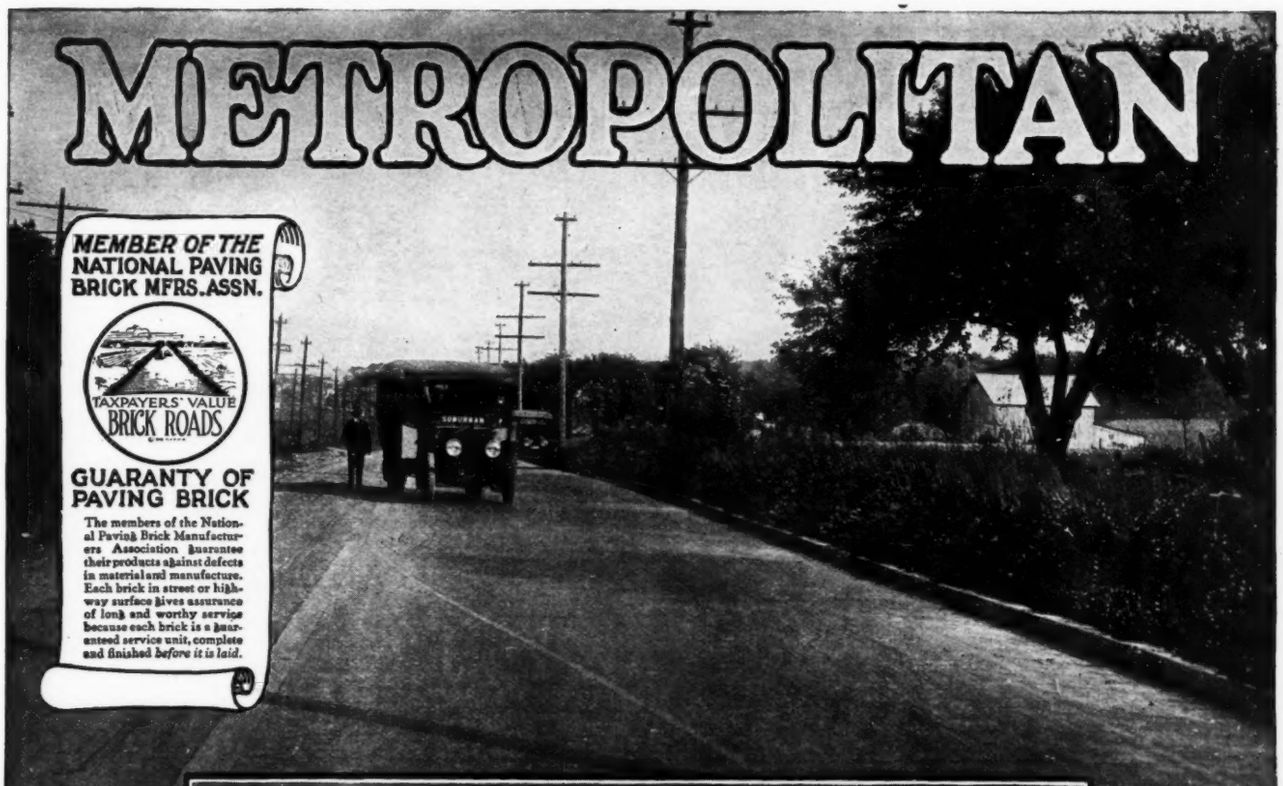
Joint Fillers (Paving).
The Barrett Co.
Philip Carey Co., The.

Kettles (Portable).
Barber Asphalt Paving Co.
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.

Manhole Covers.
Madison Foundry Co.
Dee Co., Wm. E.

Meter Boxes.
Ford Meter Box Co., The
McNutt Meter Box Co.

METROPOLITAN



MEMBER OF THE NATIONAL PAVING BRICK MFRS. ASSN.

TAXPAYERS' VALUE BRICK ROADS

GUARANTY OF PAVING BRICK

The members of the National Paving Brick Manufacturers Association guarantee their products against defects in material and manufacture. Each brick in street or highway surface gives assurance of long and worthy service because each brick is a guaranteed service unit, complete and finished *before it is laid.*

First Cost? or Cost by the Year?

How strange it always seems to those who really *know pavements* that people still argue about first cost all by itself!

First cost figures, considered apart from maintenance cost, have as much to do with deciding on a pavement as the price of astronomical telescopes.

Every engineer and every experienced public official knows that a road which costs "half as much" to build usually has cost "twice as much" at the end of ten years, and has been out of service a good part of the time, at that.

The public must have education on the road question—*now!*

And because sound knowledge of the road question leads straight to the Brick Pavement, we are doing our share toward making plain to the public the broad truths about roads and streets.

By this broad policy we shall benefit engineers and officials who want to give the public what it ought to have. And we believe we shall thus reinforce the just faith you have shown so amply in the fine products and unequalled service facilities of METROPOLITAN, the largest manufacturer of Paving Brick, or Block, in the world.

METROPOLITAN PAVING BRICK COMPANY

CANTON OHIO

BUYERS' GUIDE

Mixers, Asphalt.
F. C. Austin Co., Inc.
Barber Asphalt Paving Co.
Cummer & Sons Co., The F. D.

Mixers, Concrete.
F. C. Austin Co., Inc.

Molds (Pipe & Culvert).
Heltzel Steel Form & Iron Co.

Motor Fire Apparatus.
Acme Motor Truck Co.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
The Gramm-Bernstein Motor Truck Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.
Service Motor Truck Co.
J. C. Wilson Co.

Motor Trucks.
Acme Motor Truck Co.
Autocar Co.
Duplex Truck Co.
Federal Motor Truck Co.
The Gramm-Bernstein Motor Truck Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.
Service Motor Truck Co.
J. C. Wilson Co.

Motor Truck Flushers, Sprinklers and Oilers.
Acme Motor Truck Co.
Autocar Co.
F. C. Austin Co., Inc.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co., The
The Gramm-Bernstein Motor Truck Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.
Service Motor Truck Co.
J. C. Wilson Co.

Municipal Castings.
Dee Co., Wm. E.
Madison Foundry

Paints (Asphalt).
Barber Asphalt Paving Co.
Barrett Co., The
H. H. Robertson Co.
Truscon Steel Co.

Paving Blocks (Creosoted).
The Barrett Co.
Republic Creosoting Co.

Paving Brick.
Medal Paving Brick Co.
Metropolitan Paving Brick Co.
Murphysboro Paving Brick Co.
National Paving Brick Mfrs. Assn.
Springfield Paving Brick Co.

Paving Contractors.
Warren Bros. Co.

Paving Joint Compound.
Barber Asphalt Paving Co.
The Barrett Co.
Philip Carey Co., The.
H. H. Robertson Co.
Truscon Steel Co.

Paving Joint Filler.
Barber Asphalt Paving Co.
The Barrett Co.
H. H. Robertson Co.

Paving Machines.
F. C. Austin Co., Inc.
Cummer & Son Co., The F. D.
East Iron & Machine Co., The
Warren Bros. Co.

Paving Plants (Asphalt).
F. C. Austin Co., Inc.
Barber Asphalt Paving Co.
Cummer & Son Co., The F. D.
East Iron & Machine Co.
Good Roads Machinery Co., Inc.
Smith Co., T. L. The.
Koehring Machine Co.
Warren Bros. Co.

Pipe Dip and Coatings.
The Barrett Co.
H. H. Robertson Co.
The Texas Co.

Pipe Manufacturers.
American Cast Iron Pipe Co.
U. S. Cast Iron Pipe & Fdy. Co.

Pitch Filler.
The Barrett Co.
Warren Bros. Co.

Plows (Rooter and Wing).
Austin-Western Road Cach. Co.

Portable Paving Plants.
F. C. Austin Co., Inc.
Cummer & Son Co., The F. D.
East Iron & Machine Co., The
Good Roads Machinery Co., Inc.
Warren Bros. C o.

Portable Stone Bins.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Pumps.
De Laval Steam Turbine Co.
Smith Co., T. L., The.

Reinforcing For Pavements.
American Steel and Wire Co.
Truscon Steel Co.

Road Building Material.
Barber Asphalt Paving Co.
The Texas Co
Kentucky Rock Asphalt Co.

Road Binder.
Barber Asphalt Paving Co.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Bros. Co.

Road Forms.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Road Graders.
Austin-Western Road Machinery Co., The
Baker Mfg. Co.
Good Roads Machinery Co., Inc.

Road Machinery.
F. C. Austin Co., Inc.
Austin-Western Road Machinery Co., The
Barber Asphalt Paving Co.
Cummer & Son Co., The F. D.
East Iron & Machine Co., The
Good Roads Machinery Co., Inc.
Mayer, F.
Warren Bros. Co.

Road Planer.
Austin-Western Road Machinery Co.

Road Oils and Preservatives.
Barber Asphalt Paving Co.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.

Road Rollers.
Austin-Western Road Machinery Co., The
Barber Asphalt Paving Co.
Good Roads Machinery Co., Inc.

Rock Crushers.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Rock and Sand Heaters.
East Iron & Machine Co., The

Roofing Material.
Barber Asphalt Paving Co.
The Barrett Co.
Philip Carey Co., The.
The Texas Co.
Warren Bros.

Sand Dryers.
Cummer & Son Co., The F. D.

Sandstone.
Cleveland Stone Co.
Ohio Quarries Co.

Scarifiers.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Scrapers, Drag Line.
Pawling and Harnischfeger.
Sauerman Bros.

Scrapers, Graders, Plows, Etc.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Scrapers, Power.
Sauerman Bros.

Sewage Treatment.
Direct Oxidation Process Corp.
Electrolytic Sanitation Co.
Wallace & Tiernan Co., Inc.

Sewer Braces.
Kalamazoo Fdry. & Mach. Co.

Sewer Castings.
Dee Co., Wm. E.
Madison Foundry Co.

Sewer Cleaning Machinery.
Stewart, W. H.

Sewer Forms.
Heltzel Steel Form & Iron Co.

Sewer Pipe.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.
Vitrified Pipe Mfrs. Assn.

Sewer Rods.
Stewart, W. H.

Sidewalks (Stone).
Cleveland Stone Co.
Ohio Quarries Co.

Sluice Gates.
Coldwell-Wilcox Co.

Snow Removal Machinery.
Austin Co., Inc., F. C.
Good Roads Machinery Co., Inc.

Special Castings.
Crane Co.
Flower Valve Mfg. Co.
U. S. Cast Iron Pipe & Fdy. Co.

Sprinklers.
F. C. Austin Co., Inc.
Austin-Western Road Machinery Co., The

Steel Joists, Studs and Sash.
Truscon Steel Co.

Steel Tapes.
Kolesch & Co.
Lufkin Rule Co., The

Stone Crushers.
Austin-Western Road Machinery Co.

Stone Curbing.
Cleveland Stone Co.
Ohio Quarries Co.

Stone Elevators.
Austin-Western Road Machinery Co.

Stone Flagging.
Cleveland Stone Co.
Ohio Quarries Co.

Stone Spreaders.
Austin-Western Road Machinery Co.
Burch Plow Works Co.

Stone Screens.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Street Cleaning Machinery (Horse Drawn).
Austin-Western Road Machinery Co., The

Street Crossings.
Cleveland Stone Co.
Ohio Quarries Co.

Street Flushers (Horse Drawn).
Austin-Western Road Machinery Co.

Street Paving Material.
Barber Asphalt Paving Co.
The Texas Co.

Street Sprinklers (Horse Drawn).
Austin-Western Co., Ltd., The

Structural Steel.
Lewis-Hall Iron Works.
Minneapolis Steel and Machinery Co.

Surveyors' Instruments.
Kolesch & Co.
Lufkin Rule Co., The

Sweepers.
F. C. Austin Co., Inc.
Austin-Western Road Machinery Co., The
Elgin Sales Corp.

Tamping Machines.
Pawling and Harnischfeger.

Tanks, Water Supply.
Mensch, L. J.

Tar and Pitch.
The Barrett Co.
Philip Carey Co., The.

Tar Heaters.
Littleford Bros.

Tarvia.
The Barrett Co.

Testing Chemists.
Dow & Smith
Howard, J. W.
Kirschbraun, Lester
Van Trump, Isaac.

Traction Engines.
Austin-Western Road Machinery Co., The

Traction Engines (Oil or Kerosene).
Austin-Western Road Mach. Co.

Tractors.
F. C. Austin Co., Inc.

Trailers.
Warner Mfg. Co.

Trench Braces.
Kalamazoo Fdy. & Mach. Co.

Trench Machinery.
F. C. Austin Co., Inc.
Kalamazoo Fdy. & Machine Co.
Pawling and Harnischfeger

Trinidad Lake Asphalt.
Barber Asphalt Paving Co.

Turbines, Steam.
De Laval Steam Turbine Co.

Valves.
Coldwell-Wilcox Co.
Crane Co.
Flower Valve Mfg. Co.

Wall Coping.
Cannelton Sewer Pipe Co.

Warrenite.
Warren Bros. Co.

Water Pipe.
American Cast Iron Pipe Co.
Cast Iron Pipe Publicity Bureau

Waterproofing.
Barber Asphalt Paving Co.
Barrett Co., The
The Texas Co.
Truscon Steel Co.

Water Purification.
Direct Oxidation Process Corp.
Electric Ozone Sterilizer Co. of America.
Electrolytic Sanitation Co.
Pennsylvania Salt Mfg. Co.
Wallace & Tiernan Co., Inc.

Water Works Supplies and Equipment.
American Cast Iron Pipe Co.
Alger Supply Co.
Cast Iron Pipe Publicity Bureau
Coldwell-Wilcox Co.
Crane Co.
Flower Valve Mfg. Co.
McNutt Meter Box Co.
Pennsylvania Salt Mfg. Co.

Wheeled Scrapers.
Austin-Western Road Machinery Co.

Wire Rope.
American Steel & Wire Company

Windows (Steel).
Truscon Steel Co.

Wire-Cut Lug Brick.
Medal Paving Brick Co.
Metropolitan Paving Brick Co.
Murphysboro Paving Brick Co.
Springfield Paving Brick Co.

Wood Block (Creosoted).
Barrett Co., The
Republic Creosoting Co.

Wood Preservatives.
Barrett Co., The
Republic Creosoting Co.

MOTOR TRUCKS

Motor Trucks as Operated in Municipal and County Service and in Highway Transportation

Citizens of the United States:

What are you planning to do in 1920

Are you going to Talk, Talk and Talk some more

Are you going to Theorize, Theorize and Theorize some more

Are you going to Confer, Confer and Confer some more

Are you going to Spend, Spend and Spend some more

Are you going to Speculate, Speculate and Speculate some more

Are you going to Strike, Strike and Strike some more

OR

Will you work more
Will you produce more
Will you save more

That is the only way possible for real Americans to do their solemn duty and save the country.

There is no substitute for work

Our policy of doing business is founded on Quality and Service, and we pledge that our organization will not be found wanting in this world crisis.

The Autocar Company

Ardmore, Pa., Established 1897

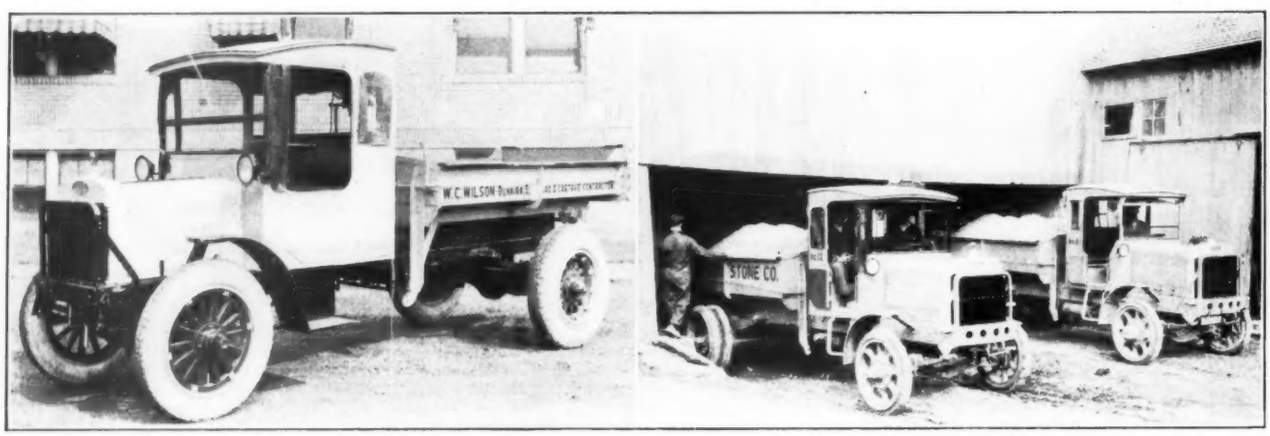
Manufacturers of the Autocar Motor Truck

This message was first published by the Autocar Company in newspapers throughout the country during December, 1919

Printed as insert to MUNICIPAL AND COUNTY ENGINEERING, February, 1920.

Motor Truck Operation and Accounting LIV

It is rather unusual to mount a dump truck on pneumatic tires, but such equipment, as illustrated in an accompanying view, possesses certain advantages. The truck illustrated is a Gramm-Bernstein Model 20, 2-tonner, equipped with hydraulic hoist and a double acting tail gate. This truck is used for hauling asphalt and for hurry-up calls by a progressive contractor, W. C. Wilson, of Dunkirk, Ohio. The square-cornered dump body gives the advantage also of permitting the loading of brick, tile and other material which cannot be easily loaded in a round-cornered body. The other half of the composite half-tone shows the two latest models of Gramm-Bernstein 5-ton trucks, which form a part of the fleet of five trucks operated by the T. C. Long Stone Co., of Lima, Ohio. During the busy seasons the T. C. Long Company's trucks are operated by three shifts of drivers, 24 hours a day. Mr. Long insists upon good drivers and daily inspections, and as a result his repair bills for the first six months of 1919 amounted to practically nothing with the exception of new tires on two or three of the trucks. This concern has been using Gramm-Bernsteins for the past five or six years.



GRAMM-BERNSTEIN TRUCKS AS OPERATED IN THE CONSTRUCTION FIELD.
Two-ton truck equipped with pneumatic tires, hydraulic hoist and dump body. Two in a fleet of five trucks operated by T. C. Long Stone Co. of Lima, Ohio.

Builders Depend Upon Trucks for Low-Cost Speed

"To meet the demand for economy and speed in renewed building operations throughout the country, motor trucks increasingly are being pressed into use," said an official of the Pierce-Arrow Motor Car Company, of Buffalo.

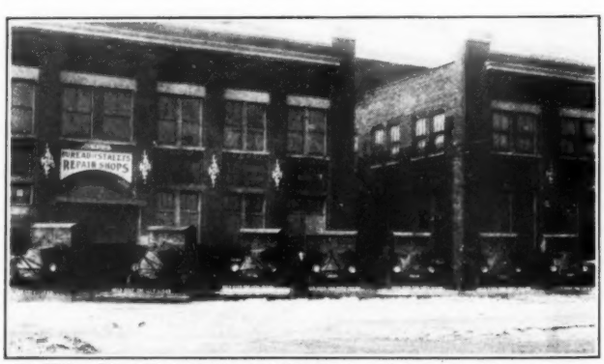
Typical instances of enterprise shown by building supply dealers who are increasing the volume and range of their business through the use of trucks may be cited in the case of two Milwaukee firms. One, the W. H. Pipkorn Company, operates three 5-ton Pierce-Arrow trucks. One of them is in its ninth year of service, performing as reliably as ever, with its original worm gear intact, after 120,000 miles of usage. The Pipkorn Company has found that each truck replaces six teams of horses, increases the radius of operation four-fold, and affords customers immediate deliveries.

During a recent month, one of the trucks in 25 working days traveled 1,204 miles, an average of more than 48 miles daily, and hauled an average of 21.2 tons daily of cement and other materials. This record has been exceeded frequently. Gasoline yields about 4 miles to the gallon.

Another Milwaukee firm using the Pierce-Arrow product is the Western Lime and Cement Company. A 5-tonner in operation since February, 1917, has traveled nearly 30,000 miles and has been virtually free from mechanical troubles. During four recent months this truck averaged 47 miles a day, hauling 149 barrels of cement. The total mileage for the period was 4,704, 14,945 barrels of cement being hauled.

Motor Plows Remove Snow from Chicago Streets

A fleet of seven Mack motor snow plows operated by the Bureau of Streets in Chicago is illustrated herewith. Their speed makes them ideal for removing the snow while it is falling. The plows are attached to the front of the trucks and are demountable. The trucks have dump bodies so that they can be utilized the year round.



FLEET OF SEVEN MACK MOTOR SNOW PLOWS, OPERATED BY THE BUREAU OF STREETS, CHICAGO.

The Brockway Highway Truck

The common practice in highway construction of dumping materials at the roadside and then transporting them in wheelbarrows and measuring them into the concrete mixer involves a variety of wastes. Material is wasted in dumping and handling and time is wasted in handling and rehandling.

These possibilities of loss are claimed to be eliminated by the new Brockway motor truck designed particularly for highway work. The body itself is of the "all-purpose" or "utility" type, with the sides and tail gate removable so that it can be used as a flat platform body. The tail gate is also arranged so it can be swung from the top or bottom. The special feature of this body is in the arrangement of the division boards. These are spaced to hold a certain measured quantity of stone or sand, or stone and sand mixed, the spacing of these boards depending upon the size of the concrete mixer. These boards are hinged at the top and held in position by three plungers that are operated by a hand lever placed outside of the body.

In operation the truck is run under the bin and the material dumped in by use of a chute. On reaching the concrete mixer, the truck is backed up to the skip and the body hoisted, the tail gate is opened and the rear compartment, which holds one charge for the mixer, dumped into the skip. After the skip returns to position, the other compartments are emptied, one at a time, merely by pulling the lever at the side. When the truck is emptied, the body is lowered and the boards swing back into position. These division boards are all easily removable so that the truck can be used for other work.

The use of this body does away with the need of wheelbarrows at the mixer, and in that way saves one handling. When hauling sand and stone mixed, the only material that has to be handled at the mixer is the cement. Another advantage is that there is no cleaning up to be done as the work progresses, as is necessary where material is dumped on the roadside.

An advantage is also claimed over the industrial railway, as no tracks are needed, and the contractor has the truck for such other work as may be necessary.

It is claimed that in actual operation on highways it has been found that this body not only saves the cost of a number of men at the loading end of the mixer, but speeds up the spreading gang, as there is absolutely no time lost in charging the mixer. The truck is made by the Brockway Motor Truck Company, Cortland, N. Y.

KISSEL DUMP TRUCK AS OPERATED BY THE GERLINGER STEEL CASTING CO., WEST ALLIS, WIS.

Emergency Pile Driving with a Motor Truck

Pile driving with a motor truck on the Salonica front is described as follows by Capt. L. S. Daynes in a recent issue of The Canadian Engineer:

Previous to the allied offensive in April, 1917, it was necessary to have the main road running parallel to the Karasule-Dorian railway put into a fit state for all traffic up to 6-in. guns. This entailed the driving of several pile bridge spans on the old Turkish road to replace those which had been previously destroyed.

The work was assigned to the various field companies in their respective areas. The crossing of the Selimb river was urgently needed, being subject to mountain torrent. The river sometimes rose from 7 to 10 ft. in less than 12 hours. The bed of the river was gravel, clay and quicksand, so a four-pile bent bridge was decided upon and the work was given priority.

The equipment supplied was a frame driver with 30-ft. leads, a 1,200-lb. hammer, and a hand-winch worked by four men. This winch was discarded after the first hour's driving and a team of horses was used, but owing to the heavy rains the ground was in such bad condition that progress was very slow.

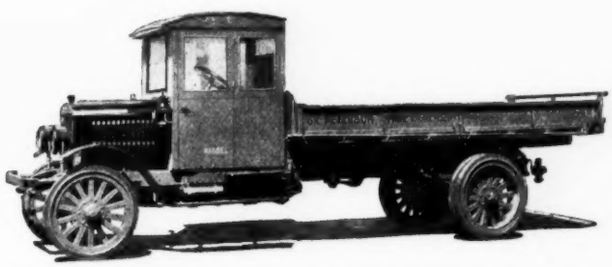
The motor transport companies were getting uneasy, and being anxious to see the bridge completed, generously offered a 4-ton Peerless truck if we could use it. Their offer was quickly accepted. The truck was set up on the west bank, the left-hand rear wheel was jacked up and blocked 10 ins. from the ground, and the other three wheels were snubbed and staked to the ground. The lead rope was given a turn on the brake drum inside the wheel, one man operating the loose end.

The distribution of labor was as follows: One motor driver, one signal man, one on lead rope, three on pile driver and two sharpening and putting on pile rings.

The piles used were 12 by 12 ins., 40 ft. long, and were placed in leads by the truck. The number of piles driven was 48 to a penetration of 24 ft. Work was continuous in three 8-hr. shifts, and the bridge was completed for traffic in twelve days. None of the sappers had had any previous experience with a pile driver. After the completion of the bridge, the truck was tested for strain or deflection of axles, and was found to be in as good condition when returned as it was when received.

The New Federal One Ton Model

The 1 ton field is the most overcrowded of any capacity truck today; overcrowded as to models and as to prices. Too much stress, however, has been placed upon low prices, excessive speed and extremely light weight construction.



KISSEL RESERVE POWER AND STRENGTH MAKE KISSEL TRUCKS VALUABLE FOR CONTRACTORS.

The new Federal 1 ton, shown for the first time in New York and Chicago National Truck Shows, is built strictly in accordance with Federal standards of real, hard-duty service. The essential features worked out in the new 1 ton Federal, therefore, are: a governor control speed of 25 miles per hour; pneumatic cord tires, pressed steel frames, disc steel wheels, heavy support radius rod, electric lighting equipment lamps on swivels which can be turned to point where light is needed most, special hard service battery and generator, thoroughly proven power tire pump, steel seat and dash.

The officials of the Federal Company are certain from the demand created before this truck was put on the market that it has a place of its own in motor transportation. It has all the sturdy lines of the larger Federals with the additional feature of speed. It is a heavy duty truck for light loads, not a cut down passenger designed chassis with heavier members and springs. It is not a makeshift in any sense of the word; but it is backed by a thoughtful and careful design with the main purpose of giving successful and continuous service.

Gasoline Economy

The following suggestions on gasoline economy are offered by C. H. Davies of S. F. Bowser & Co., Inc.:

First, a great deal can be saved through care being used by the driver of the car in different ways, such as throttling down the motor whenever possible, not permitting the motor to idle at the curb for extended periods of time, and not attempting to make the motor work under extremely difficult pulling conditions or picking up on high gear in traffic.

Second, various derangements about the motor should be promptly eliminated. If the motor misses, a condition is produced which is not conducive to gasoline economy.

Often an owner will find it necessary, due to extremely cold weather or some condition about his car, to prime the motor before starting, particularly on mornings when the car has remained standing over night. In drawing out the gasoline to accomplish this priming, there is considerable gasoline used, which ofttimes an owner does not take into consideration when figuring the mileage he is obtaining.

Of course, the proper adjustment of the carburetor is responsible to quite a large extent for the mileage obtained, but it is necessary, in order to obtain the most economical adjustment of the carburetor, that the different adjustments about the ignition system be correctly made.

In cold weather particularly, one may occasionally notice indications of water in the carburetor in gasoline. This may be brought about through condensation in changes of temperature. Water in the gasoline is very disagreeable and may be serious. It doesn't take any longer and doesn't cost any more to be served with filtered gas. Bowser gasoline pumps have a water separator or filter built right into the pump which takes all of the water and dirt out of the gasoline as it is delivered to your car. It really pays to play safe and buy only filtered gasoline.

In winter weather the motor should be kept in a warm garage if possible. It can easily be realized that with the motor warm the gasoline economy will be greatest. We have experimented extensively in order to determine the best running temperature for the motor, and have found with the water at a temperature of 170 degrees F. that the best results are secured in regard to the economy of gasoline. In cold weather with the temperature 10 to 20 degrees above zero, we have found that without the hood covered or some portion of the radiator that the temperature of the water is on an average of 120 degrees F. For this reason the owner should cover up a sufficient portion of the radiator and hood to insure running at a temperature of 170 degrees F.

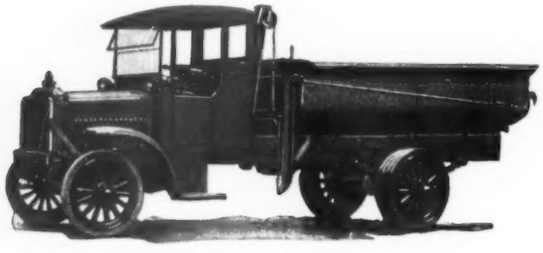
Transportation Engineering is Added to New York University Curriculum

A course in Motor Transportation Engineering is to be added to the curriculum of New York University, to begin in February, according to an announcement made by Dean Charles H. Snow, of the School of Applied Science.

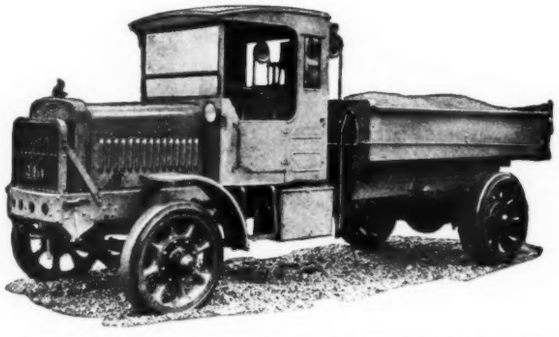
The new study, which is considered a clear indication of the ascending importance of motor truck transportation, is to be given by F. Van Z. Lane, Chief Transportation Engineer of the Packard Motor Car Company, Detroit. It will form a part of the new course in Industrial Engineering and will be open to students in Mechanical and Civil Engineering, particularly those specializing in subjects relating to Highway Engineering.

The course will have more to do with the application of the motor truck than the mechanics of it, according to Mr. Lane. "The motor truck is part of the mechanical equipment of every industry, and engineers entering any industry must become more familiar with its application," he says. "The course in Motor Transportation will deal solely with the application of the truck as a transportation unit in industry and is not to be confused with motor truck design.

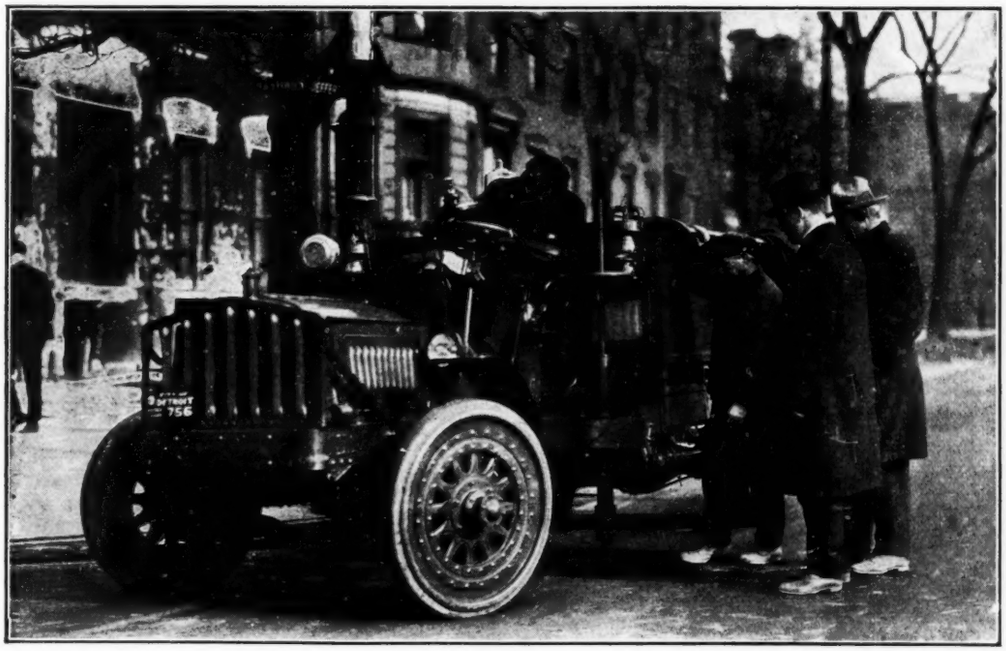
"It has been proved, under the most trying circumstances, that the motor truck is mechanically dependable



GRAMM-BERNSTEIN 2-TON DUMP TRUCK WITH ROUND CORNER STEEL BODY.



NEW MODEL 5-TON GRAMM-BERNSTEIN TRUCK WITH SQUARE CORNER STEEL DUMP BODY EQUIPPED WITH B. A. GRAMM'S PATENT POWER TAKE-OFF DEVICE FOR OPERATING HOIST MECHANISM.



Specially-equipped Packard Truck closing Water Gate in City Water Main, Detroit. When a main is broken and property is being damaged, the only truck of any value is the one that is always ready for service.

Is the City Official Always Ready for Emergencies?

IN Detroit damage from broken water mains is cut to the minimum by the use of this special Packard Truck that reaches any point in the city a few minutes after the alarm is given.

For over two years this truck has been operating the water gates of Detroit. It saves the labor of four to eight men and closes the gates in less than one-fourth of the time formerly needed.

It is the day-by-day dependability of the Packard that makes it peculiarly suited for such emergencies.

THE Packard is supervised from the ground up by the one responsible Packard organization. Every part of every Packard Truck is designed, tested and controlled by the Packard Company from start to finish.

Packard engines are tested on the block to an equivalent of 1,000 miles road service. A Packard Truck is "run in"—ready to do a full day's work the day it is delivered.

The City Official who feels his responsibility wants the safeguard that Packard transportation affords in every emergency.

"Ask the Man Who Owns One"

PACKARD MOTOR CAR COMPANY, *Detroit*

and that by applying it correctly it is an economical means of transport and that to get the most efficient service from their equipment those in industry should understand how it can be used with the greatest effectiveness. New York, which is the largest user of motor trucks in the country, is a huge laboratory for this work.

Mr. Lane is a graduate of New York University, which conferred upon him the degree of C. E. for traffic work accomplished, probably the first degree ever awarded for this kind of work. He was an engineer in the Brooklyn Highway Department, was Engineer in Charge of Traffic on the Brooklyn and other East River bridges and later held a similar position in the Department of Public Works, Borough of Manhattan, where he had charge of gathering statistics relative to the widening of a number of important streets. He was the first Traffic Engineer employed by New York City and laid out some of the most recent routes for the operators of motorbusses there and in Chicago. He was Executive Engineer on the Bayonne Marine Terminal and, as Engineer to the Chamber of Commerce at Jersey City, was instrumental in promoting the vehicular tunnel now under construction between that city and New York. He has served various City Plan Commissions, municipalities, civic organizations and industries as Transportation Engineer and has studied the subject abroad.

This course is the first of its kind to be given by any University in connection with industrial study, and will include the following lectures: The Future of the Motor Truck, Motor Truck Operating Costs, Motor Truck versus Horses, Motor Truck versus Railroads, Trailers and Semi-Trailers, Special Bodies, Loading and Unloading Devices, Scheduling, Routing and Dispatching, Maintenance and Garaging, Hiring, Training and Retaining Drivers.

New Model Diamond T 2-Ton Truck

A four speed transmission, a special "Dri-gas" intake manifold and vacuum feed system for the fuel designed to obtain best results from present low grade gasoline, forced lubrication for all spring shackles, and bearing carriers for the propellor shafts are among the features of the just announced Model U 2-ton motor truck brought out by the Diamond T Motor Car Company. Like the other Diamond T trucks, the new vehicle is worm-driven.

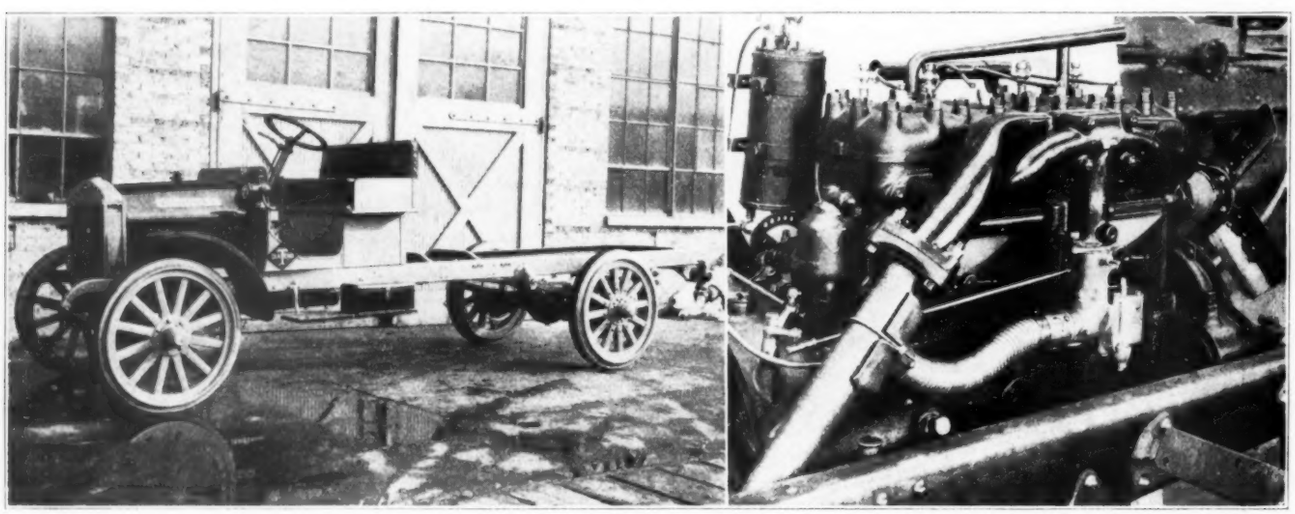
The four speeds give unusual low reduction in the transmission; fourth speed, 1 to 1; third speed, 1.60 to 1; second speed, 2.69 to 1; first speed, 4.75 to 1; reverse, 5.95 to 1. The transmission was designed for heavy duty under severe operating conditions and all gears are of nickel steel with wide tooth faces for carrying heavy loads.

A vacuum system has displaced the gravity feed for the fuel supply. The special "Dri-gas" manifold, the combustion chambers and intake passages have been designed to obtain the best possible efficiency and economy from the low grades of gasoline now on the market. The Stromberg carburetor is used and there is a dash adjustment to facilitate starting. Ignition is furnished by a Bosch high-tension D U-4 Magneto. The unit power plant is a block casting of four cylinders, 4 in. bore and 5¼ in. stroke with and S. A. E. rating of 25.6 h. p. and a maximum of 43 h. p. at 1,800 revolutions a minute. All the valves are on one side and have removable heads. Three point suspension with a patent-applied-for ball and socket joint as the rear motor support, is used for the engine.

The Alemite process of forced lubrication for all the spring shackles enables the lubricant to be quickly and surely injected into the lubricating cups by the use of a special device that does away with haphazard lubrication at these points. Oilless bushings—bronze impregnated with graphite—are used as bearing surfaces for brake cross shafts, starting crank shaft and foot pedals.

A long whipping propellor shaft is eliminated by using a special Diamond T bearing carrier. Double universal joints are used between the transmission and rear axle, with slip joint to allow for spring action. Between the clutch and bearing carrier universal joints of the Thermoid-Hardy type are used, connected by heat-treated propellor shaft welded to the joints by a patented process. The rear propellor shaft, between bearing carrier and rear axle, is equipped with the standard all-metal Spicer universal joints.

Like all other Diamond T trucks, perfected Hotchkiss drive is used and radius rods are eliminated. The semi-elliptic springs are made of chrome-vanadium steel and each leaf is tested separately. The front spring has 9



NEW MODEL DIAMOND T 2-TON TRUCK AND ITS ENGINE.

DUPLEX TRUCKS

BUILT FOR BUSINESS

Allison, Iowa
April 17, 1919

Gentlemen—

I wish to state that Butler County has owned a Duplex Truck since the middle of 1917 and have received first-class service and satisfaction from same.

We consider that a four wheel drive is the only kind of a truck for our work. We have used this truck for everything that a county could possibly use it on.

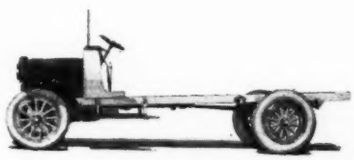
We have hauled bridge material of all kinds, gravel, dragged our roads, driven piling, pulled eight-foot grade, and also used it to pull in a tractor which broke down.

The cost for 1917 per ton-mile, exclusive of depreciation and interest, was 16 cents; with depreciation and interest, 23⅔ cents.

Yours truly,
D. W. BURCH,
County Engineer.

Duplex Limited

Medium Capacity—Two Wheel Drive—High Speed
$2575 F. O. B. Lansing



DUPLEX 4-Wheel Drive Trucks are typical examples of American progress. They occupy a prominent place in every line of the road building business and their prestige is permanently fixed in the minds of business men.

Yet it is little wonder that increasing numbers of road contractors are learning about Duplex performance and applying it to their own business. Merit soon establishes a standard and the buying public are quick to sense a leader.

Duplex Truck success is due to a number of things but mainly to their performance—their dependability. Profitable truck operation can come only from constant service.

Get all the facts about Duplex Trucks. You will find them interesting and perhaps profitable.

Duplex 4-Wheel Drive

3½ Ton Capacity. Price $4250, f. o. b. Lansing.

DUPLEX BUILT FOR BUSINESS

Duplex Truck Company
Lansing • Michigan

One of the Oldest and Most Successful Truck Companies in America

leaves, 2¼ in. wide and 40 in. long. The rear spring has 12 leaves, 2½ in. wide and 53 in. long.

The truck weighs 4,800 lbs. The tires are solid, 36x4 in. front and 36x7 in. rear. The fuel tank, with a capacity of 18 gals., is located under the seat. The equipment includes a Klaxon warning signal, a special governor built into the motor, hubodometer, front fenders of extra heavy steel, oil side and tail lights, complete set of tools, tool box and seat.

MACK "AC" DUMP AND TANK TRUCKS USED FOR ROAD BUILDING BY THE TWENTY-THIRD U. S. ENGINEERS, FRANCE.

Motor Truck Beats Railroads on Freight Delivery

"That the motor truck can deliver freight in better time than the railroads was recently demonstrated in California," says H. P. Branstetter, Chicago, Kissel distributor. "Between Los Angeles and San Francisco motor trucks have delivered freight from consignor to consignee in 55 hours or less, while it sometimes takes a week or ten days to deliver the same freight by railroad trains, which in addition necessitates its being hauled several times before its ultimate delivery.

"While in this particular instance the highway between the two cities mentioned is ideal for minimum time, it nevertheless demonstrates the fact that if the proper highways are built, the motor truck can hold its own in competition with any mode of transportation on land, both as to time, dependability and low expense."

The Motor Truck Traffic Manager

"With the advent of the motor truck a new business or profession has taken its place in American business circles —that of the Motor Truck Traffic Manager," says H. P. Branstetter, Chicago Kissel distributor.

"The business of the Motor Truck Traffic Manager is to study the area over which his trucks operate in the hauling of goods, supplies and material. The function of his job is to deliver and haul goods in the quickest possible time and at the least operating cost per ton mile. To accomplish this he should have at his finger tips the shortest and best route to any given destination—the location of terminals and transfer points—the loading and unloading facilities of every business concern and house he does business with. He must even have it figured down as to the exact time a truck of a given size, loaded with a certain tonnage will arrive at a given point.

"The Motor Truck Traffic Manager also informs himself regarding mileage between all points—location of garages, service station and supply depots, and should in addition be an expert in the efficient loading and unloading of all kinds of motor truck bodies.

"All of these specific points the Motor Truck Traffic Manager has before him as each load is sent out. He occupies the same position as the Train Dispatcher on a railroad system. By thus operating his truck along these lines he does not duplicate area, and cuts out immense waste of gasoline and oil and wear on tires. And if the operation is carried out accurately, and systematically, all of the trucks can be in the home garage at a certain time at the end of the business day."

THE VALUE OF HIGHWAY TRANSPORT SURVEYS

By F. Van Z. Lane, Chief Transportation Engineer, The Packard Motor Car Co., Detroit, Mich.

In the field of highway transport there has been a colossal number of failures and reports of new transportation companies that have failed are received almost daily. If these debts, the money losses represented by these failures—failures due in a large part to the absence of transport surveys—were the sole reason for the development of such surveys, their value would run into millions.

Insurance against failure is, however, but a small part of the real value of highway transport surveys. Many companies in existence today would, if such investigations were generally resorted to, be able to render greater service to the public and make increasing profits for themselves, and these surveys would undoubtedly establish the desirability of highway transportation lines where as yet such lines have not even been thought of.

Many Failures

The prevalence of failures, paralleling the failures in the automotive industry in its early days, and the number of lines that are operating with a minimum of benefit to themselves and to their public, indicates the most cursory analysis of the territory to be served, or no analysis at all. Many firms are floundering without chart or compass, and we should do all in our power to correct the prevalent opinion that all that is necessary is to buy a motor truck of any make you please and any capacity offered, to start it operating over any road available, during any time of the day or week when the driver feels like it, and to charge any price for his services that may come into his head, just so long as it is lower than any other price charged for transportation between the points in question.

Just as long as the public has this picture of motor transport lines, just so long will the motor truck incompletely realize its effectiveness. That it can be effective has been proven beyond a doubt. As a mechanical device it has demonstrated its dependability and durability, and we have enough experience to know that economically it can perform, and must be made to perform more and more, its function as part of the transportation system of this country.

Learn Cost of Delivery

The hauling and delivery problem of every business should be surveyed in order that the most efficient means

Ship by Truck

3½ Ton Worm Drive
Gramm-Bernstein

Ready for the Body; Not an Extra to Buy

Gramm-Bernstein Worm-Drive trucks carry, at the listed sale price, $500 to $550 worth of equipment, according to type and size.

This equipment is all essential to truck efficiency and economy. Any truck must have it. On the Gramm-Bernstein it is listed as follows:—

Standard Gramm-Bernstein cab, with doors and storm curtains.

Exceptionally rugged metal ventilating windshield.

Front fenders and steps.

Sturdy radiator guard, attached to frame independent of radiator.

Radiator shutter, operated from seat—facilitates starting, saves gasoline.

Boyce motometer, to indicate temperature of engine.

Army truck type towing hooks at front end. Spring trailer drawbar at rear, on larger types.

Electric generator. Side lights with dimmers and non-glare lenses; dash light; bullseye tail light, protected in frame; electric horn.

Patented Gramm-Bernstein always-in-mesh transmission, with outside filler spout.

Patented wick oilers on all spring bolts.

Metal license brackets, front and rear.

100,000-mile hub odometer.

GRAMM PIONEER BERNSTEIN

Real Saving at the Start; Real Saving in the End

Without question, the complete equipment of the Gramm-Bernstein chassis is an important item of added value. It is even more. For it represents an out-and-out saving, of $500 to $550, in the cost price of a truck.

We believe all business men will agree to that. But that is not the big basic reason for choosing Gramm-Bernstein. We want our buyers to go deeper, right down to fundamentals.

We want them to satisfy themselves, first and foremost, that Gramm-Bernstein *is* a better truck for their particular work.

We want them to know that it *is* a greater value.

We want them to consider, not only the individual units, but the sound engineering and manufacturing experience that selects and brings them together.

We want them to assure themselves, beyond the last least doubt, that Gramm-Bernstein *is* longer-lived, that it *does* more work, and harder work, at lower cost.

These facts are easy to arrive at. They are easy because they *are* facts, and because any of our dealers can supply them.

No business man is justified in making a truck investment without first accurately informing himself.

You can't go far into Gramm-Bernstein records without discovering that high duty at low cost is their big, outstanding feature.

You will find, also, a really remarkable volume of repeat orders. Nothing but owner-satisfaction can account for that.

And owner satisfaction goes directly back to what we have said above.

Call in our dealer and have him lay the Gramm-Bernstein facts before you.

All Gramm-Bernstein Transmissions are provided with a pad for attaching Gramm's Basic Patent Power Take-off. Dealers and truck owners should assure themselves that any trucks purchased with power take-off do not infringe B.A. Gramm's Basic Patent No. 1194994.

The Gramm-Bernstein Motor Truck Co., Lima, Ohio

Pioneers since 1901—Builders of the First Liberty (U.S.A.) Truck

GRAMM-BERNSTEIN

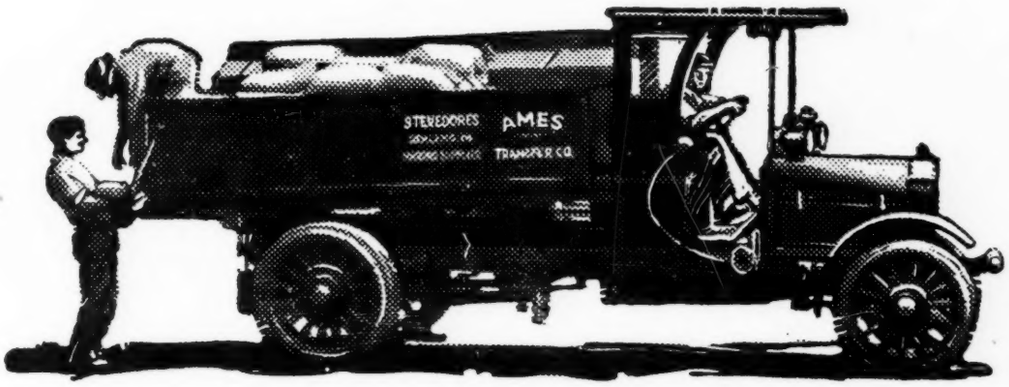
48

of the First Fifty

Pierce-Arrow trucks are still running after 8 years. Their initial cost has been distributed over 8 years. Each added year they run it will spread further.

Buy reliability. Every day a truck is off the job it is costing money and losing earnings. Your truck should last for years and earn profits every mile it runs.

THE PIERCE-ARROW MOTOR CAR COMPANY, Buffalo, N. Y.



No. 25 has served the Ames Transfer Co., New York, for 8 years. Tried out in competition with mule teams formerly used, its record was so good these teams were all displaced by Pierce-Arrows.

They standardize now with 36 Pierce-Arrows, each bought with profits earned by the trucks.

The actual mileage covered by No. 25 is in excess of 150,000 miles. The original worm still serves with no evident diminution of power.

Pierce Arrow

Delivers more work in a given time.

Loses less time on the job and off the job.

Costs less to operate and less to maintain.

Lasts longer, depreciates less and commands a higher resale price at all times.

of transportation can be used, particularly in reference to the highways. It is astonishing how little most concerns know about the cost of the delivery and hauling end of their business. The concern that usually knows its labor, production, accounting and selling costs, many times has no idea of what its delivery cost is. Yet the delivery and hauling part of the business usually amounts to a great deal. A survey of such a problem will often indicate that it would be more economical to ship or deliver by motor truck than by horse-drawn vehicles, railroad freight or express, or by boat or electric railway. In considering a transportation system the nature and character of the business it serves should be considered first.

What a Survey Will Show

The proper kind of a survey will bring out all the items entering into the cost which would never be brought out in any other way. For instance, I had occasion the other day to make a survey of the shipping part of a business concerned with the rolling of steel products. This was a large concern with a railroad siding right into its plant. Its products take a very low freight rate and its deliveries are mostly to points located within 60 miles of the plant. Yet this survey showed that the motor truck could be used to better advantage than the railroad, that it could transport material cheaper and exactly as it was wanted.

This survey developed, for example, that the average cost per box used to contain the material was $1.25 and that the average weight of these boxes was 42 lbs., something that the traffic manager of this concern had never considered before in his transport problem. Motor trucks are now being used by this company, thus releasing several freight cars for use where the railroad is the more economical means of transport.

The proper sized truck, the most adaptable kind of body, and the use of loading and unloading devices will many times serve to handle the hauling problem more economically and more efficiently.

Such a survey should take us behind the lines, so to speak—back of the loading platform, into the shipping room, where we could consider such items as boxing, crating, sorting, assembling, routing, internal delivery, etc. It is here that, oftentimes, a study will show how the use of highway transport can cut down the cost of the work leading up to placing the material on the truck or on the car.

Items to Consider in Making Surveys

In making surveys relative to the establishment of highway freight transport lines, the following items should be carefully considered:

All-year-round road conditions, including bridges;
Rail freight and express rates;
Frequency of existing service;
Time of delivery of existing service;
Amount of, and kind of, freight moving in both directions between the points in question;
Running time possible;
Sentiment of the district under consideration toward existing and proposed service;
Sufficient financial support;
Traffic laws, ordinances and regulations.

Road conditions will determine the kind of equipment that can be operated. The amount and kind of freight will determine the size of the unit, and number necessary, from which can be determined the expense, to which should be added (this is most often omitted) overhead charges, by which I mean the cost of soliciting business, storing and handling of same, superintendents, etc., and which for such lines runs very high. The cost of operation will determine the rate. This, compared with existing rates and services, will determine whether or not business can be secured under such costs. The possibility of promoting return loads should not be forgotten. This, you will note, is quite different from the usual method of arbitrarily determining a rate, which is probably that charged in some other locality and without knowledge of actual conditions.

ONE OF TEN 3½-TON SERVICE MOTOR TRUCKS USED IN EXCAVATING THE LARGEST SWIMMING POOL IN THE SOUTH, AT LOUISVILLE, KY.

Another FEDERAL

Municipal Popularity

The man who selects machinery, materials or trucks for the Municipal use is usually more careful even than when he buys for himself.

His judgment is at stake—he must be sure now-a-days that the public is served efficiently.

That is one of the reasons why many municipalities are using Federal Motor Trucks.

Among the many municipalities owning Federal Trucks is the city of Pasadena, California. Officials of the street department are emphatic in their high praise of Federal performance as typified by the work of this truck.

When it devolves upon you to select a motor truck for your city or county, why not find out the reason why Federals are so popular with city and county officials generally?

"Traffic News"—the Magazine of Haulage—sent free on request.

FEDERAL MOTOR TRUCK COMPANY
35 FEDERAL STREET DETROIT, MICH.

"Shorten the Miles to Market"—"Use Motor Trucks"

This Federal Truck is owned by the City of Pasadena, Cal. It is operated by the Street Department of that city.

ACME

What 21 per cent of
Acme Trucks *Prove*—

Over 21 per cent of all the **Acmes** built go into engineering and construction service, so an investigation shows. This proves that everywhere the **Acme** is being recognized for its inbuilt ability to give satisfaction in this type of service.

The reason for **Acme's** success lies in proved construction. The **Acme** Seal is your bond of the industry's proved units correctly assembled by experienced engineers in a well-balanced truck. It is your assurance that the truck contains *only proved* units. In addition, **Acme** owns and operates its own wood-body and steel-body building plants, enabling us to deliver trucks complete, ready for service, for your particular type and size of job.

Built in 1, 1½, 2, 3½ and 5 ton models

Select a truck which engineers and contractors bank on—that is built for, and proved in, engineering and construction service. Write for our complete catalog which tells about **Acme** Proved Construction and Proved Units, together with a record of **Acme** in service.

Acme Motor Truck Company
188 Mitchell Street CADILLAC, MICH.

The Seal of Dependable Performance

Trade Mark Registered

In a survey of the possibility of establishing inter-city motor truck routes out of a certain city, recently made, we concluded the lowest capacity truck that could be operated, considering the rate that could be obtained, would be a 3-ton size. Yet the operators disregarded our advice and started in with 2-ton trucks. If loaded to 80 percent of their capacity on every trip, in both directions, they couldn't pay—and didn't—the result being the failure of another line and the loss of much confidence.

All this information is very easy to get if gone after in the proper way. Most communities now have commercial organizations which will be very glad to assist in the accumulation of such data.

Reliability in such service is absolutely necessary. In the case of highway passenger transport, the number of passengers will determine the seating capacity desired and the frequency of operation, which, together with the length of haul, will determine operating expenses, and therefore the fare that must be charged. Here again reliable service must be inaugurated, as reliability is important in all transport matters.

There is no more important question before the public today than that of highway transport surveys, and if this organization can succeed in putting some interest into this subject, it will have accomplished a big work.

The foregoing is from a paper by Mr. Lane before the 1920 annual convention of the National Highway Traffic Association.

"This Job is No Fun"

Said Jim, the driver. "I have to keep this old truck on the jump from morning till night, and the only chance I get for a loaf is at noon. It used to take me twenty minutes to load from the cars. Then the truck and I got a nice, long breathing spell. Now that **'Lightning' Loader Skip** is always waiting for us. I drive up, zip! The truck's loaded in two minutes and I'm off again."

The owner smiled quietly. The truck cost him $12.00 a day, and Jim and three shovelers $6.00 a day each. He knew that now he was getting their full service, and saving around $10.00 a day.

A "Lightning" Loader Skip is the most expensive equipment—to be without.

Write for Literature

The Heltzel Steel Form & Iron Company
WARREN, OHIO

KISSEL TRUCKS

5 capacity models

FOURTEEN years of automotive experience have brought to Kissel a knowledge of how to build trucks that stand up under abnormal demands.

The dominating thought in every step, from selection of materials to finished chassis, has been to *"build to prove equal to exceptional trucking service."*

Kissel engineering practice insures perfect balance of units. Power balances weight and both harmonize in gear ratios. Axles and bearings do their part without adding needless weight.

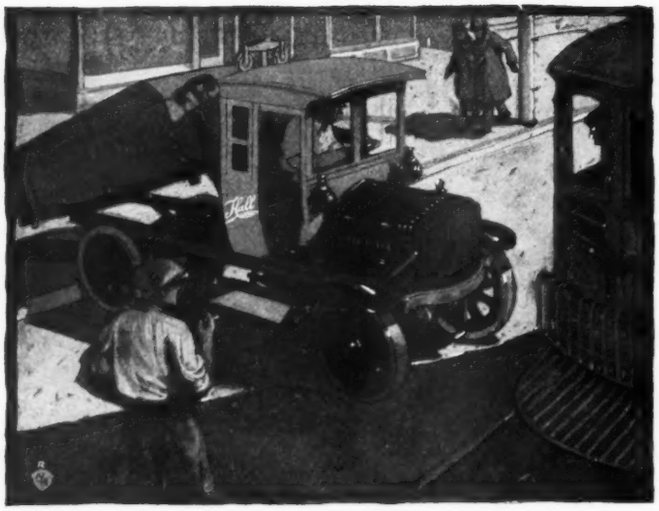
Some of the foremost industries have been using Kissel Trucks for years—industries whose trade expansion has demanded reliable trucks.

The Kissel Truck distributor can save you money and time and increase your haulage efficiency. See him.

KISSEL MOTOR CAR CO.
HARTFORD, WISCONSIN

HAUL IT IN A HALL

THE HALL "SHORT-SPECIAL" TRUCK



Announcing the New HALL "Short-Special" Truck
Especially adapted for the needs of congested city traffic

The HALL "Short-Special" meets an actual and vital demand. It fills a need in the work of city trucking that puts it in a class of its own. It reduces time of loading, haulage, delivery, and consequently increases hour-mileage and lowers cost per ton haul—all points that spell increased service and operation economy for truck owners of every class.

Among the outstanding advantages of the HALL "Short-Special" truck in city work is the fact that it will take the shortest street and alley turns easily, and can be backed up to curbs on streets used by street car lines without interfering with the regular stream of traffic.

Write for folder which gives complete details and specifications. Address Sales Manager, No. 19 Roby Street, Detroit, Michigan.

As Manufactured by
The LEWIS-HALL IRON WORKS
DETROIT, MICHIGAN.

EDITORIALS

LET US HAVE CO-OPERATION, NOT COMPETITION, BETWEEN ENGINEERING SOCIETIES

The great majority of engineers are in favor of co-operation calculated to further their non-technical interests. General agreement has been reached on this point, but there is still a difference of opinion as to procedure toward this end. Some engineers, how many we have no means of knowing, appear to favor a form of super-organization of the founder societies, or a federation of all societies for this purpose, but a very great many favor leaving the non-technical interests of engineers in the hands of the American Association of Engineers which is demonstrating its ability to safeguard those interests.

In the recent report of the Joint Conference Committee of the older societies no reference is made to the fact that the proposed work has already been undertaken, and is well advanced, by the American Association of Engineers which now has a membership larger than that of any other national society.

In deliberately ignoring the very useful work of the American Association of Engineers the Joint Conference Committee has offended many engineers and has subjected itself to a great deal of adverse criticism. Engineers have not forgotten that these older societies were deaf to all appeals for aid of the most vital character for many, many years. It is so obvious as to require no argument that the unprecedented growth of the American Association of Engineers was made possible only by widespread dissatisfaction with the cold attitude of the old societies toward the non-technical interests of engineers. There is no escaping the conclusion that the growth of the Association is a stern rebuke to the old societies and quite possibly this growth has aroused the resentment of the Bourbon element in the profession, and in ignoring the facts this element is running absolutely true to form.

This magazine is not interested in advancing the interests of any engineering society over those of another so long as the interests of engineers are not placed in jeopardy. But this magazine does believe in a square deal and we assert that the action of these older societies in ignoring the hard, conscientious and effective work of the Association is offensive to our conception of fair, square conduct. Moreover, there is nothing in the past history of these old societies to warrant any one in concluding that their conversion to liberalism is permanent. Many feel that if the American Association should quit the field today the old societies would quickly settle back in the smug and comfortable attitude they held for many decades, in effect bidding the individual engineer sink or swim, survive or perish, without so much as stretching forth a hand to help him.

The interests of these old societies have always been technical in character and they will remain largely or wholly technical, save for spasmodic concessions to liberalism. If there is among the governing class of the old societies a sincere desire at this time to help the individual engineer, in a material way, let them co-operate with the American Association of Engineers in its labors on behalf of all engineers.

KEEPING UP VERSUS CATCHING UP

Readers of engineering journals sometimes complain that successive issues contain little that is new. These friendly critics assert that issue after issue simply records facts relative to happenings in the construction field in various parts of the country; they say that what they are given from time to time is but a rehash of old stuff.

That there is a degree of justification for this criticism cannot be denied, but it is very easy for the faithful reader to be over-critical and it is still easier to miss entirely the true significance of the condition criticised.

Technical journals do not create news, they merely collect and disseminate it. When the progress of the art is rapid this is reflected in the records; conversely, when progress is slow the news value of the journals drops to its lowest point.

But the significant aspect of this matter leaves the engineer and the engineering journal in equally dignified positions. The engineer is steadily progressing and the journals of his profession follow him very closely. His progress is by evolution rather than by revolution. His improvements are gradually effected, and often his rate of progress is so slow as to be almost imperceptible to the constant observer. He is progressing steadily if slowly, however, and while it is easy to keep up with him it is very hard to catch up once you fall behind.

Men who have been in and out of engineering or engineering journalism realize keenly that the art of engineering is constantly changing for they have found that they have much ground to make up if they lose contact with engineering affairs for a year or two. The change from week to week or month to month is easily assimilated but the change from year to year is so great as to be comprehended only with a great effort.

Not a few engineers have concluded that their journals bring them so little that is new that reading is a

waste of time, only to find themselves greatly embarassed by their demonstrated ignorance of developments within the profession familiar to all who have kept up with the procession.

Thus the individual engineer must choose between keeping up with ease or catching up with difficulty or of deliberately joining the back numbers.

THE CONSTRUCTION TRIANGLE

There was a time, not so long ago, when a graphical representation of the three principal factors in the construction industry would hardly have taken the form that now comes first to mind. The three factors mentioned are the engineer, the contractor and the material man. The engineer and the contractor would have been graphically represented, in that period now happily past, by two parallel lines. These lines always "kept their distance" and never really got together except at an infinite distance from where things were happening. There can be no doubt of this part of the graph. When we consider representing the material man as a part of the same picture we are less confident of our ability to represent him in a form acceptable to all critics. Some would have represented him by a series of exclamation points, undoubtedly, and others by a question mark large or small as individual opinion dictated. Some would have represented him by a line crossing the other two at right angles, while still others would have made his angles of intersection at once obtuse and acute.

But now this most interesting and serviceable graphical representation of the three factors takes the form of a triangle, and an equilateral triangle at that. In the presidential address at the recent annual convention of the American Road Builders' Association, the word "us" was used to include the engineer, the contractor and the material man by a president who is the state highway commissioner of one of our greatest states, a man who has come to think of these three elements jointly.

The triangle, be it remembered, is the symbol of strength and rigidity. It is the truss element. Let us make it truly symbolical.

THE DICTATED ARTICLE

At this time when engineers are so busy it is well to consider the merits of the dictated engineering article. In this period of high pressure activity in the construction industry there is little time for composing articles in ornate diction and in literary style. Unless the engineer resorts to the dictated article, therefore, he will fail to make the contributions to the literature of his profession that he should make. He is very busy because he has extraordinary opportunities to achieve developments in the practice of his profession, and the great trust imposed in him by the public carries with it the obligation to report for the use of others the knowledge he gains.

It is often stated that the set papers delivered at conventions are of less interest and value to the practical man than the discussions inspired by the papers and this is quite true. The long, set paper is comparable with the carefully written article and the short practical discussion is comparable with the dictated article. If these discussions by men unaccustomed to public speaking are so useful to the profession it follows that the same men, in the easier atmosphere of their own offices, could dictate short articles, or discussions if you please, that would be even more helpful to other workers in their field.

With the unprecedented opportunity now enjoyed by every engineer to try out his theories in practice he should observe many things worthy of record. We urge that he use the dictated article to report his observations and impressions. If the name "article" sounds too formidable why not say discussion or letter? Engineers are as quick to write letters as they are slow to write articles, so why not write "letters to the editor" instead of articles? It is assumed that letters are dictated, and it is generally recognized that a letter does not necessarily represent the maximum skill of its writer in the selection and arrangement of words. Thus the author of a letter need give little thought to possible criticisms of his composition. Give the editor the naked facts and figures and leave it to him to clothe them as their needs may require.

Unless workers in the construction field adopt these suggestions in principle and act on them we are all going to lose a great deal of immediate value. Let us tell our stories while we work, not afterwards. Let us exchange information while it possesses maximum usefulness, rather than record ancient history after the next industrial depression is upon us.

CO-OPERATION IN THE HIGHWAY FIELD

A splendid spirit of co-operation is beginning to take form in the highway field. Never before have engineers, contractors and material men regarded each other with so much toleration and esteem. Each class realizes it can do nothing by itself, that team-work is required to protect class and individual as well as public interests. Engineers have come to realize that they should co-operate with the contractor as well as to sit in judgment on his work. This changed attitude is reflected in the support the cost plus form of contract is receiving from engineers. Contractors must be fairly dealt with and protected against hazards beyond their control. We anticipate that before long cost plus contracts in some improved form will be legalized in the public works field. Engineers are now getting something of the contractor's viewpoint and see his side more clearly than ever before.

This spirit of toleration is due in part to necessity, lest the contractor become extinct and to the abundance of opportunities for all, but it is due also to the normal development of the industry.

SERVICE THE FINAL TEST OF QUALITY OF ROAD STONE

By H. Eltinge Breed, Consulting Engineer, 507 Fifth Ave. New York City

There is shortage of materials for highway work. Yet certain traditions prevent our utilizing all available sources. With road building still so young a science, it is startling to discover the large part that dogma is playing in its development. Startling on the one hand because we have liked to believe that we were progressing in accordance with scientific methods of investigating and experiment, and it is disconcerting to find ourselves prejudiced by empirical judgments—startling on the other hand because we find that the very definiteness and apparent accuracy of research may give rise to delusive opinions. The matter has been brought forcefully to my attention in respect to the qualities of stone.

Limitations of Rattler Tests

We have judged stone by the rattler test and rated it according to the French coefficient of wear. The harder stone with a higher coefficient was adjudged the best, because it offered the greater resistance to the wear administered by the rattler test. By analogy it was assumed that it would likewise offer greater resistance to the actual test of service under traffic. It was assumed, without proof, that wear upon stones in a pavement would be relatively the same as was the wear upon stones in a rattler. This assumption I believe to have been unsound, because it ignored this fact:—stones in a rattler are a loose aggregate; stones in a pavement are a more or less compact mass.

It is obvious that the looser the type of pavement the more closely will the wear upon stones under actual traffic approximate the wear in the rattler test; that is, in the looser types, each stone, like the stones in the rattler test, is a unit offering individual resistance to the friction of traffic upon it. In so far as each stone in the pavement is a separate unit the accuracy of the rattler test may be accepted in determining the standard of stone to be used.

Rattler Test Not Sound for Rigid Types of Pavement

But in those rigid types of pavement where the stones, far from being separate units, are simply parts of a compacted mass, then, I believe, the rattler test is not sound, its apparent accuracy is misleading, and the conclusions we have drawn therefrom false.

Because in the rigid types of pavement it is not the stone alone, it is the whole pavement that offers resistance to traffic. It is not the stone, but the lack of mortar strength that causes disintegration. The stone is merely one elemen in the whole. True, if it were the weakest element, it might be held responsible for failures. This possibility has been safeguarded by repeated experiments in both laboratory and field which have demonstrated that the wear of stone with the French coefficient of from 6.5 to approximately 7.5 is equivalent to the wear of the matrix of a concrete pavement in service. To use stone of a lower coefficient would be an unwarranted risk. On the other hand, to use stone of a much higher coefficient is unnecessary, often expensive, and, I believe, sometimes detrimental to the pavement.

Stone has been the determining factor in the success of so many types of pavement, that when we come to the rigid type known as the concrete pavement we failed to realize that its importance had relatively lessened. We did not see it in relation to the whole.

Quality of Stone in Concrete Road

No concrete pavement is stronger than the matrix that holds it together. When the matrix disintegrates the pavement disintegrates. Every failure in concrete roads has been traceable to dirty aggregates, faulty mixture, or wrong methods of laying. Never once in my experience have I found the qualities of the stone itself to blame, i. e., where it had a French coefficient of 6:5 or better. This fact taken in conjuction with the remarkable success of concrete roads built with stone of a low French coefficient led me to consider afresh the problem of the serviceability of stone.

Rattler Test Not a Positive Determinant

I wondered whether we were not laying too much stress upon the value of the rattler test as a positive determinant. Should it not be regarded rather as a deterrent from using materials that are flagrantly below the standard? How far can you really gage the strength of a road by the strength of each of its component parts? In roads like the water bound macadam, very adequately, because in each individual part there is the individual resistance to traffic wear. In respect to a concrete road, not at all, because the resistance to traffic is determined by the whole structure and not by any one element on it. The relation of the stone to the strength of the road is the sum total of the resistance to traffice that the road will offer. If the stone is harder than the matrix, the wear is going to be uneven. This is demonstrable in many of our concrete roads. The sands and cements have worn down from the surface faster than the stone, and roads have become roughened under heavy traffic. Then there is always danger that these slightly uneven pieces of hard stone may be chipped out and increase the disintegration of the pavement. The softer stone shows a more uniform wear; that is, it rubs down with the other elements in the pavement and the whole road is kept in a smoother condition by its use. The final test of any piece of pavement is wear under traffic. The greatest destructive factor upon a pavement is impact whose force is intensified by uneveness.

Specific Examples

A piece of concrete pavement that I have had under inspection refutes the idea that all stone shall be deemed excellent for all purposes in proportion to its French coefficient. The section I have specially watched was completed in 1914—five years ago, in proportion 1 : 1½ : 3 of standard cement, clean Long Island sand, and Tomkins Cove limestone with a French coefficient of 7.1. It is part of Highway 5301 in Suffolk County, New York. Here are the locations at which this stone was used. From Station O-O to Station 245-O and from Station 265-O to 273-O section 19; from 12-O to 76-O on section 20, approximately six miles in length.

The condition of this pavement on October 9, 1919 showed the surface wear amounting to less than ¼ in.—hardly enough to obliterate the broom marks. There was no wear at cracks, none at joints, a smooth uniform surface, and a mosaic appearance. This in spite of the fact that it has stood the severest traffic stress under impact from very heavy and very swiftly moving vehicles.

An actual traffic census has not been taken on the six

miles under examination, but the traffic density may be estimated by the census that has been taken on the two roads contiguous to it. It shows on road 5488 in 1916 as follows:

Total horse drawn traffic.....343 tons daily
Total motor drawn traffic.....3090 tons daily
Total motor truck traffic..... 936 tons daily

It shows on road 793 in 1916 as follows:

Total horse drawn traffic.....187 tons daily
Total motor drawn traffic.....782 tons daily
Total motor truck traffic.....453 tons daily

This traffic has been immensely increased since 1916 by traffic going to and from Camp Upton, to which our road is a feeder.

This specific instance is supported by 29.04 miles of pavment built in western New York from Buffalo limestone with French coefficient of from 6.5 to 10. They have been laid about the same length of time as the road we have cited, and show the same uniform wear.

The following is a tabulation of this work:

Road No.	Miles	High & Low Coefficient as Shown by Test	When Constructed
1214	5.89	(9.3 to 7.7	Part built in 1915
		(10.5 to 5.7	Part built in 1916
5434	2.01	7.4	Part built in 1914
5453	3.61	7.4	Built in 1914
5217A	6.23	(10 to 8	Part built in 1915
		(10 to 7.6	Part built in 1915
5245A	5.95	10 to 7.6	(Part built in 1915
			(Part built in 1916
5263A	5.35	10 to 7.6	Part built 1915-16-17

Value of the Impact Test

If we regard as of only partial value the laboratory tests upon the component parts of the concrete pavement, it becomes more than ever necessary to have a test for the pavement as a whole which shall serve as a standard of measure. This, I believe, is found in the impact test. It takes a piece of finished concrete as a whole and pounds upon the surface of it in a way that approximates the actual wear of traffic. And it proves beyond question that while the limestones, or other stones with low French coefficient show a slightly greater loss in weight than the very hard stones, yet this loss, in the final wear upon the pavement, is more than compensated by the greater uniformity of surface wear. These experiments were carried out by Mr. Mattimore in the New York State Laboratory in Albany, and were described by him, with graphic illustrations in an article entitled, "Wear-Resisting Values of Various Aggregates for Concrete Roads Indicated" found on page 861 of the Engineering News-Record of May 2, 1918.

Thus scientific research and experiment seem to corroborate the conclusions suggested by experience;—we can no longer generalize safely about all stone; we must consider a particular stone in relation to its particular function in a specified type of pavement. And the concrete type is better built with stone whose wearing quality is most nearly commensurate with that of the matrix. That is, with stone with a French coefficient of from seven to nine.

HIGHWAY WORK IN NEW ENGLAND IN 1920

The following data on highway work in New England in 1920 is given by Col. Wm. D. Sohier, formerly chairman of the Massachusetts State Highway Commission:

I am showing the amounts of money that will be available in the various New England states during 1920 for highway work: (The amount available in Connecticut is given as for two years, 1920 and 1921, this including Government Aid, was $9,640,000 for construction and maintenance; I have divided that amount to get an average for one year.)

MONEY AVAILABLE AND HIGHWAY WORK TO BE DONE IN NEW ENGLAND IN 1920

State	Miles of State Highway Construction & Reconstruction	Cost	Miles Maint.	Cost
Maine	150	$4,500,000	4,500	$800,000
State Aid	100-125	1,250,000	....	.....
New Hampshire	100	1,250,000	1,500	750,000
Vermont	75	1,323,000	1,518 patroled	
(4,339 miles maintained under State supervision and with State help)			2,821	450,000
Massachusetts—				
S. H. & Fed. Aid....	100-125	3,300,000	2,286	1,200,000
State Aid	100	1,500,000	....	.....
Reconstruction	60	1,250,000	....	.....
Poor Town Roads....	.....	.....	5,500	450,000
Rhode Island	30-40	1,300,000	333	350,000
Connecticut	140*	3,845,000	1,627	2,000,000
	855-915	19,518,000	20,085	6,000,000
		6,000,000		
Total available		$25,518,000		

*Estimated.

BUILDING STORM WATER SEWERS IN HAMILTON, OHIO

By Roger B. McWhorter, Assistant Division Engineer, The Miami Conservancy District, Hamilton, Ohio

Three concrete, storm water sewers have recently been built in Hamilton, Ohio, by the Miami Conservancy District, as a part of the local flood protection work. The sewers total 4,160 ft. in length and are from 4 ft. to 5 ft. 8 ins. in size. The largest of these sewers is located on Buckeye St. Another is located on Wood St. and the the third is located on Front St. The following description by Mr. McWhorter of these sewers and their construction is from The Miami Conservancy Bulletin for December, 1919.

The Buckeye Street Sewer

There is an area in the northeast part of the city from which the storm sewers drain into the tail-race, which until recently, flowed northerly to Old River. This tail-race was a part of the Hamilton and Rossville hydraulic and was abandoned for power use with the other parts inside the corporation limits. Its outlet was closed by the Old River improvement, and the sewers that empty into it are now served by the Buckeye Street intercepting sewer, which connects with the tail-race. The maximum flood stage to be expected at Buckeye Street is elevation 589.5 ft., or about 3.5 ft. lower than at the tail-race outlet, a noteworthy advantage of the new location.

This sewer is made of reinforced concrete, horseshoe shaped, inside dimensions 5 ft. x 5 ft. 8 ins. and is 1,868 ft. long. Figure 1 shows its cross-section and design of forms in detail. It connects with the tail-race 300 ft. east of Fourth Street and runs westerly, 9 ft. north of the south curb, to the river. The elevation of the flowline at the connection with the tail-race is 577.0 ft. There is a change in grade at Third Street, 740 ft. from the tail-race. Above

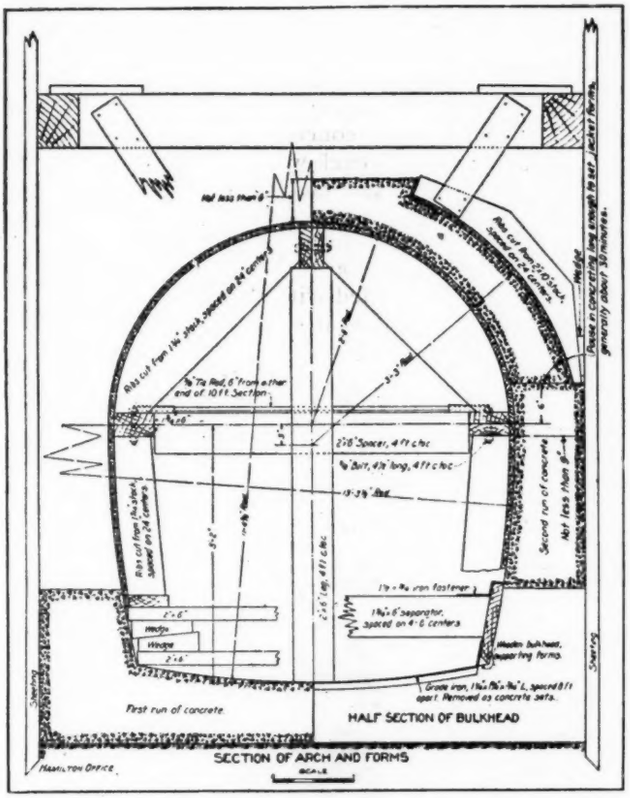


FIG. 1. CROSS SECTION OF BUCKEYE STREET STORM WATER SEWER, HAMILTON, OHIO.

Cut also shows design of forms in detail and methods employed to hold them in place, also shows sequence of concreting operations.

this point the grade is 0.45 percent and below it 0.40 percent. The sewer has an inside sectional area of 24.5 sq. ft., and is capable of discharging about 200 cu. ft. per second. There is a gate manhole about 70 ft. back from the outlet, in which a floodgate will be operated during extreme flood stages. A standard manhole was provided at each street intersection, through which there can be no overflow, even with the floodgate out of commission, as the street surface is from 6 in. to 6 ft. above the maximum flood level. The gate will protect the ground surface from flooding should the river level approach the top of levee, which at Buckeye Street, is 4 ft. above the estimated maximum flood level.

Excavation—The excavation was begun at the lower end of the trench, the plant used consisting of an electrically operated traveling derrick, fitted with a ¾ yd. clamshell bucket, and mounted on a 28 ft. gage track, straddling the ditch; one 24 in. gage Plymouth gasoline locomotive, four 1½ yd. rocker dump cars, and 420 ft. of track laid with 30 lb. rail. The track was placed alongside the ditch at a convenient distance for the derrick to load the cars. The amount of material by which the excavation exceeded the backfill was wasted on the river bank south of the outlet to be later removed by the large river excavating machine. The depth of cut ranged from 14 to 24 ft.

A stratum of hard, tough, blue clay, varying in thickness from 4 to 7 ft., and lying from 8 to 10 ft. below the surface, was found, extending from the outlet to a point some 450 ft. up the trench. This material was difficult to remove and impeded the progress, increasing the expense considerably during the first month or so. Dynamite was used, but not very effectively. The clay proved to be too soft to blast and too hard to be handled satisfactorily by the clamshell. West of Front Street the material other than the clay consisted of cinders and loam. From Front Street to Fourth Street, 3 or 4 ft. of surface loam was underlaid by clean gravel and sand, suitable for use in concrete.

Because of the nature of the soil and the depth of the trench continuous sheathing of the sides was necessary. Fig. 2 shows the method of shoring the trench.

A street railway line runs up Third Street to Black Street, under which the sewer trench was passed, thereby necessitating an interruption of the service north of Third Street. As the patronage on that part

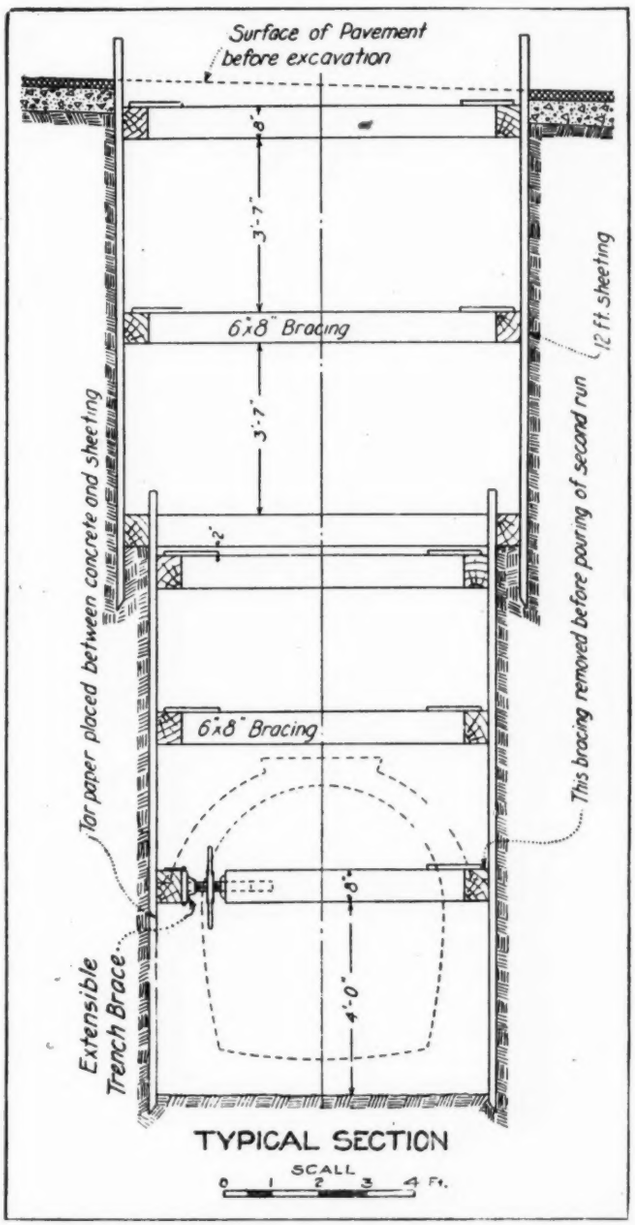


FIG. 2. METHOD OF SHORING THE TRENCH FOR THE BUCKEYE STREET SEWER, HAMILTON, OHIO.

of the line is small, except during the early morning and late afternoon hours, the service was suspended during the day for the few days the derrick was working over the track. Provision was made to pass the cars up to 8:00 a. m. and after 4:00 p. m.

The double track main line of the Baltimore & Ohio Railroad crosses Buckeye Street at Fourth Street, and the sewer was carried under these tracks by means of a tunnel. The tunnel was 48 ft. long. of cap and leg construction, sheathed overhead and on the sides. The

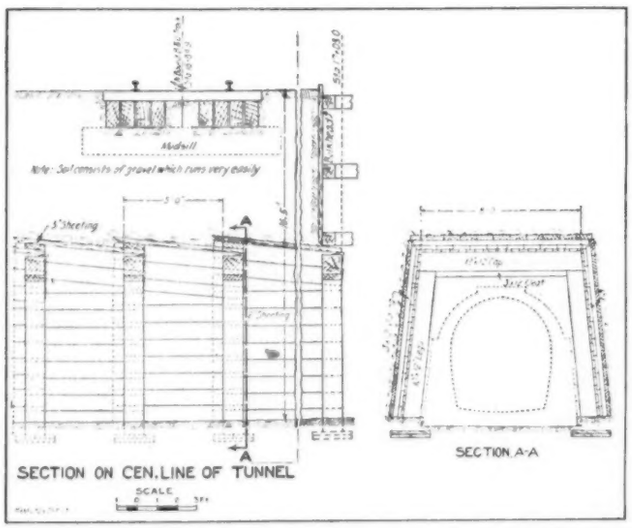


FIG. 3. TUNNELING UNDER THE B. & O. R. R. AT HAMILTON, OHIO, IN STORM SEWER CONSTRUCTION.

sections shown in Fig. 3 give an idea of the manner in which the tunnel was built. To guard against possible settlement of the tracks four 8 in. x 16 in. stringers, 30 ft. long, were placed by the railroad company symmetrically under each rail, each resting on four 16 in. square mudsills, one placed on either side of the trench and one at either end of the stringers. After completing the sewer through the tunnel the remaining space was packed full of loam sand, care being taken to leave no voids. The temporary timbers under the tracks were then removed, and the original condition restored.

Concrete—A ½ yd. Smith portable tilting mixer and wood chutes were used for mixing and placing the concrete. The "trench run" material supplied both the fine and coarse aggregates, as frequent screening tests made throughout the work indicated that no screening was necessary. These tests, through ¼-in. screens, showed the ratio of gravel to sand, with only one exception, to range from 2½:1 to 2:1. Sufficient cement, as determined from the tests was used to maintain a ratio of 1:2 between cement and sand, and enough water was used to make a mix that would move down the chutes with slight assistance from a hoe or shovel. Both water and aggregates were heated during freezing weather, and the fresh work was covered with tarpaulins under which salamanders were placed. However, the winter of 1918-19 was very mild, and heating was necessary in only a few instances. A layer of tar paper prevented the concrete from coming in contact with the sheeting.

Fig. 1 shows in detail the forms used, and the methods employed to hold them in place. It also shows the sequence of the concreting operations. Forms were left in place till the second day after concrete was placed, usually from 40 to 48 hours.

Backfilling—The backfilling was done by shifting the dinkey track so that the cars could be dumped into the trench. A stream of water was played upon the fill constantly and lumpy material was not allowed to remain unpuddled. The backfilling was kept close up with the concrete, and the sheeting was pulled soon after the trench was filled. A heavy timber "horse" and a block and tackle rig were used for this purpose, the power being furnished by either the gasoline locomotive or a 5-ton motor truck. Voids left by the sheeting were flushed with water. Elevations taken in sanitary sewers near the trench and parallel to it showed no settlement. However, it was necessary to remove parts of the pavement adjacent to the sheeting, because of the poor condition of both the concrete base and the wearing surface.

The street was repaved about three months after the backfilling was completed. A 10-ton road roller was

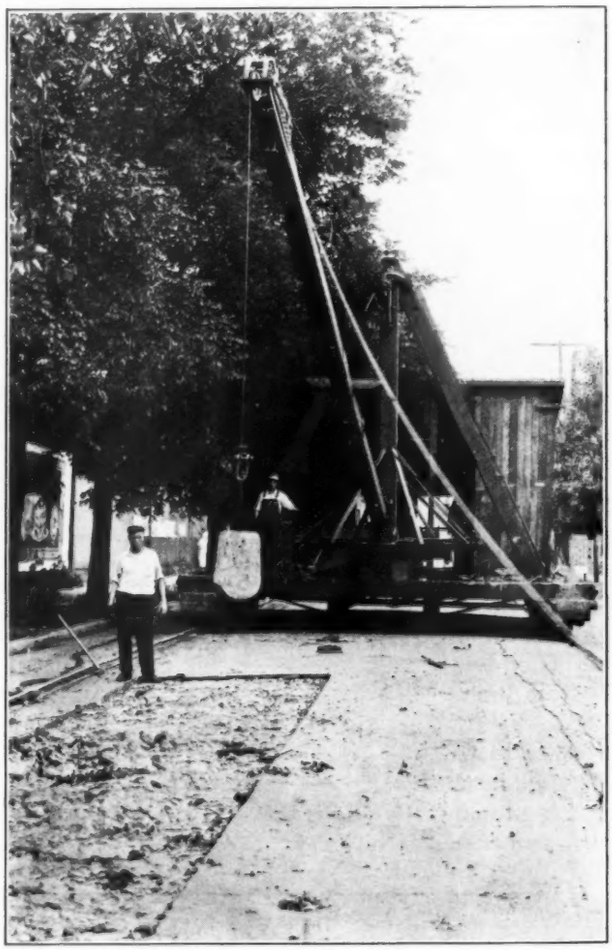


FIG. 4. BREAKING CONCRETE PAVEMENT BASE, ON SEWER CONSTRUCTION, HAMILTON, OHIO.

The 6-in. concrete pavement base on Wood Street was broken by dropping a 1-ton hammer on it, worked by the excavating derrick, thus averting the laborious process of breaking it with a sledge. At Buckeye Street the concrete base, owing to its inferior quality, was readily removed by the clam-shell bucket.

used to compact the sub-grade, upon which a 6 in. base of 1:2½:6 concrete was laid. The asphalt was placed by the Andrews Asphalt Paving Co. of Hamilton.

The sewer was begun in August, 1918, and completed in April, 1919. The quantities were as follows: Earth excavation 11,453 cu. yds.; rock excavation, consisting of old foundations and concrete base, 303 cu. yds.; concrete 1,133 cu. yds.; reinforcing steel 79,600 lbs.

Wood Street Sewer

In the central part of the city there is an area of about 132 acres, which until recently was served by a storm sewer on Wood Street discharging into the river north of the Columbia bridge. This sewer has a manhole at each street intersection, and as the surface of Wood Street, west of Second Street, is below the maximum flood stage to be expected (elevation 586 ft.), it was necessary to place a floodgate at its outlet. A reinforced concrete circular storm sewer, 4 ft. in diameter and 1,588 ft. long, has been built on Wood Street, from Second Street to the river, parallel to the old sewer, to drain by gravity during extremely high river stages the 106 acres of the aforementioned area lying above elevation 586 ft. The desired condition was obtained by building a tight sewer and connecting it with the old sewer at the existing manhole at Second Street, leaving a dead end on the old sewer at which a standard manhole was built. The elevation of the flowline at the connection is 580 ft. (the street surface here being elevation 590 ft.) and the new sewer is built on a grade of 0.6 per cent, having a capacity of a little over 100 cu. ft. per second. On the river side of the levee the old sewer was connected with the new one, a gate manhole being built in the old sewer at the levee. Thus for all ordinary stages of the river the 26 acres still served by the old sewer are drained through the outlet of the new sewer. There are no manholes or other openings in the new sewer except a standard manhole at the center line of the levee, the top of which at elevation 589, is flush with the top of the levee. West of the levee the sewer is of horseshoe shape, on a grade of 9.7 per cent. As precaution against underwashing the outlet structure and the horseshoe portion of the sewer were built on timber piles. The piles under the outlet structure range from 23 to 28 ft. in length, and the balance from 15 to 20 ft.

The excavation, concreting and backfilling operations were practically the same as at Buckeye Street, the same plant being used. The depth of cut was 18 ft. at the outlet, and ranged from 7to 10½ ft. on Wood Street. The deepest excavation was about 6 ft. below the river level at that time, necessitating pumping, a 4 in. centrifugal pump driven by a 25 h. p. electric motor being used. Wood Street is paved with asphalt on a concrete base east of Monument Avenue, and to facilitate its removal the concrete was broken, by dropping a 1-ton hammer on it by the derrick as shown in Figure 4. The asphalt was cut by an improvised rolling disc, placed on a pin between the timbers, and wedged under the derrick.

The street has not, as yet, been repaved. This will be done in conformity with the original specifications.

The job was begun April 9, 1919, and completed July 31, 1919, the quantities being as follows: Earth excavation 4,600 cu. yds.; rock excavation 186 cu. yds; concrete 665 cu. yds.; reinforcing steel 21,700 lbs.; timber piles 900 lin. ft.

Front Street Sewer

There is an area lying between Wood Street and South Avenue that has been served by a storm sewer that runs southerly on Front Street to a manhole at the old Crawford's Run crossing, thence westerly in an open channel to the river. A sewer connecting the

FIG. 5. STORM WATER SEWER TRENCH IN WOOD STREET, HAMILTON, OHIO.

The fine loamy sand on this portion of the sewer required but little shoring. The water main seen against the bank was successfully jacked over from the middle of the trench without interrupting the water service. It was necessary to recalk only a few of the joints.

manhole with the low ground east of Front Street serves the old Crawford's Run drainage area. The outlet was closed by the recently constructed levee, and a plain concrete circular sewer, 4 ft. in diameter and 704 ft. long, has been built to drain the areas mentioned, which total about 112 acres. This sewer connects with the manhole referred to, and runs southerly along Front Street to South Avenue, thence westerly to the river. The maximum flood stage to be expected at its outlet is elevation 585 ft. The elevation of the flowline at the upper end is 567.44 ft., and the grade is 0.55 percent., the maximum capacity being about 100 cu. ft. per second. This location was selected with the idea of draining still another area, farther south, in the event of a storm sewer being built on South Avenue. The cross-section of this sewer is the same as that of the Wood Street sewer. There is a gate manhole at the intersection with the levee, back of which no openings were placed.

Construction methods were the same as at the other sewers, but the trench was not completely backfilled because this portion of Front Street is within the limits of the spoil bank to be filled by the excavation from the river channel. The average cut was about 12 ft., and the material removed consisted mainly of rubbish from the city dump. This part of

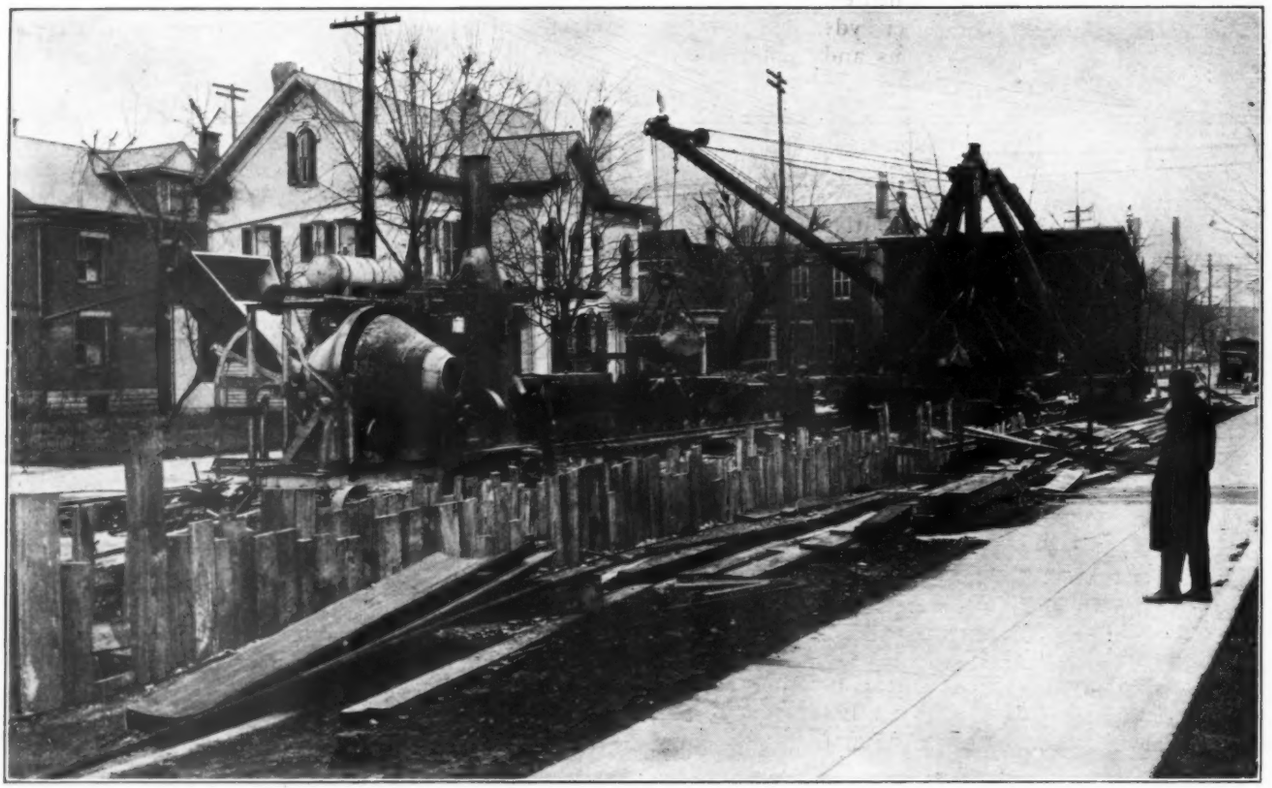


FIG. 6. EQUIPMENT USED ON CONSTRUCTION OF BUCKEYE STREET SEWER, HAMILTON, OHIO.
Smith portable tilting ½-yd. concrete mixer; 3-ton Plymouth gasoline locomotive and four 1½-yd. side dump cars; portable electric derrick with ¾-yd. clamshell bucket.

Front Street has never been paved. Excavation began Aug. 13, 1919, and the sewer was completed Oct. 18, 1919. The quantities consisted of 2,750 cu. yds. of earth excavation, 310 cu. yds. of concrete, 1,700 lbs. of steel, and 680 lin. ft. of timber piles.

C. H. Eiffert, Division Engineer, is in charge of the local flood protection work at Hamilton, and the writer, as Assistant Division Engineer, has had direct charge of the sewer work. F. C. Williams served as superintendent from the beginning of the work to March 1, 1919, when he resigned and was succeeded by W. A. Roush.

PROPOSED SCHEDULE OF SALARIES FOR ENGINEERS IN COUNTY HIGHWAY SERVICE

The Committee of the American Association of Engineers on Salaries of Engineers in Public Service invites discussion of the proposed recommendations for salaries for engineers in county highway service before presenting it to the Association for final adoption.

As was the case with the positions listed for engineers in state highway service so it is with those here listed for county highway service, they are not to be interpreted as an outline for an organization for any particular county, but merely a list of positions with the corresponding salaries. The number of persons in a given position and the number of positions in a county office will depend upon the amount of highway work a given county is called upon to perform.

The Committee has recently completed its recommendations as to salaries for engineers in state highway service, which, after wide publicity and general discussion and having been approved by the American Road Builders' Association and the Association of State Highway Officials, has been submitted to the executive committee of the American Association of Engineers by whom it has been adopted. In studying the salaries for engineers in county highway service it will be useful to compare them with those recommended for engineers in state highway service published in the November 1919 issue of Municipal and County Engineering.

The Committee on Salaries of Engineers in Public Service consists of S. C. Hadden, Editor of "Municipal and County Engineering," J. H. Prior, Consulting Engineer on Public Utilities, Chicago; A. R. Hirst, State Highway Engineer, Wisconsin; F. H. Newell, President of the Association, and A. N. Johnson, Chairman, Consulting Highway Engineer of the Portland Cement Association.

Preliminary to drafting the recommendations for engineers in county highway service the following served as corresponding members of the Committee:

William A. Hansell, Supt. Public Works, Fulton Co., Atlanta, Ga.; W. A. Stinchcomb, County Engineer, Cuyahoga Co., Cleveland, Ohio; Leroy C. Smith, County Engineer-Manager, Wayne Co., Detroit, Mich.; George Diehl, Engineer, Erie Co., Buffalo, N. Y.; F. G. Tegtmeier, Engineer, Everett Co., Snohomish, Wash.; R. M. Morton, Engineer, Sacramento Co. Highway Comm., Sacramento, Calif.; George Quinlan, Co. Supt. Highways, Cook Co., Chicago, Ill.; E. A. White, Engineer, Pierce Co., Tacoma, Wash.

So that fullest discussion may be had and the largest

amount of information possible placed at the disposal of the Committee, each engineer receiving this is particularly requested to send his comments, whether of approval or disapproval, to the chairman of the committee. Address A. N. Johnson, Chairman, Committee on Salaries of Engineers in Public Service, American Association of Engineers, National Headquarters, 63 E. Adams St., Chicago.

The proposed schedule of salaries for engineers in county highway service follows:

Administrative Positions		
County Highway Engineer. In charge of all county highway and bridge construction and maintenance.	$5,000	$12,000
Engineers of Construction. Supervises all road construction and maintenance work, both contract and force account.	3,600	6,000
Engineer of Bridges. In charge of preparation of designs and specifications and construction of bridges.	3,600	6,000
Office Engineer. In charge of preparation of plans, specifications and estimates.	3,600	6,000
Senior Engineering Positions		
Assistant Engineers. Assigned to Office Engineer in preparation of plans and estimates computing and drafting, may act as chief draftsmen.	$2,400	$4,000
Assistant Engineers. In charge of tests and materials inspection.	2,400	4,000
Assistant Engineers. Assigned to Engineer of Construction or Engineer of Bridges acting as inspector of construction, also as chief of survey parties.	2,400	3,000
Junior Engineering Positions		
Draftsmen, Computors, Transitmen, Levelers	$1,800	$2,400
Rod and Chain Men, Tracers.	1,200	1,500

REPAIRING BITUMINOUS MACADAM WITH COLD PATCHING MATERIAL IN PHILADELPHIA

By Wm. C. Bailey, Asst. Engineer, Bureau of Highways, City Hall, Philadelphia, Pa.

We had in Philadelphia a section of road on a through main traffic route which was resurfaced with a bituminous macadam wearing surface on an old water bound base about seven years ago, the surface of which was becoming very wavy and, in some spots, open. Our method of repairing this condition was as follows:

With spikes in the wheels of a road roller, enough holes were picked in the surface thoroughly to perforate it, having the holes about 4 ft. apart. All loose broken pieces were then swept off the road and the surface was thoroughly rolled. A cold mix, consisting of ¾ in. stone, sand and cold patching tar, (low carbon base) was then spread on the road in a sufficient quantity to make an even surface, in no place exceeding 2 in. in thickness, covered with about 20 lbs. of ½ in. trap rock chips per square yard and compacted with roller. This material was mixed at a central store yard in a mixer and hauled by auto truck to location where needed.

About two weeks after the road had been patched in the above manner, the entire section was given a surface treatment of Hot Oil, Asphalt Base, using about 1/5 gal. per square yard, and covered with 20 lbs. of ½ in. chips per square yard.

This road has been finished for about six months and is still in good condition, although being on a main road which is subjected to very heavy traffic between Philadelphia and Norristown, Reading and Bethlehem.

STANDARD SPECIFICATIONS FOR BRICK PAVEMENTS

By Maurice B. Greenough, Secretary, National Paving Brick Manufacturers' Association, Engineers Bldg., Cleveland Ohio

I Introduction

The paving brick industry through its Associations, has had the privilege since 1906 of placing in the hands of engineers and public officials specifications for brick pavement construction. The genuine demand that has always existed for this co-operation on the part of the industry (never more active than at present) has been met to the best of its ability. No effort has been spared to keep the specifications of the industry in accord with the best engineering practice.

Progress in highway transportation has been rapid in the last 14 years. New requirements have been laid upon pavements of all kinds. Various revisions have therefore been made in the National Paving Brick Manufacturers' Association specifications as they were needed. To meet local requirements most efficiently the several local subdivisions of the National Association have likewise issued specifications similarly revised as conditions have changed.

The first specifications issued by the Association provided for all types of brick pavements. They covered concrete, rolled stone and gravel bases, No. 2 paving brick bases and natural soil foundations. Fillers were sand, bituminous and cement grout. The bedding for the brick was sand. These specifications therefore offered a *wide range of choice* in meeting local conditions.

It must be recalled, however, that as far back as 1906 very much less attention than now was paid to subsoil drainage. The weakened condition of foundations saturated with water, overlaid by a pavement with sand and bituminous fillers (and from other causes that will be discussed later), produced a temporarily favorable attitude among engineers toward these types. For a number of years the requests for specifications covering these types of construction amounted practically to nothing, although they were then and afterward included in all

specifications published by the National Association. The great demand in nearly all parts of the country *east* of the Mississippi river was for the cement grout filled type of pavement laid on the sand cushion. Since there was so strong an expression of desire on the part of engineers for this type, it is but natural that the industry co-operated in its development.

The last previous revision of specifications made by the National Association followed the bringing out of the green concrete foundation type and its near-relative, the semi-monolithic type.

The time has come however, when a complete revision and co-ordination of all specifications of the industry is needed in order to align the industry with the progress of engineering thought in brick pavement design and construction. Also, to take advantage of the opportunity so greatly widened, created by greater experience and study in all matters of street and road improvement for public welfare. The study of paving economics has been intensified in the last few years as the importance of highways to the public has increased.

It has been proved conclusively that there is no universal type of brick pavement nor do engineers longer hold out expectation of one. They are convinced that flexibility of type is a distinct advantage of the public rather than a liability. *This is the keynote of specifications for brick pavements shortly to be presented to the public by the National Paving Brick Manufacturers' Association and its Member Associations.*

Fully to gage the value and significance of the new Standard and Alternate Specifications there is needed a brief review of brick pavement history. It should prove to be interesting and illuminating.

II History

By far the greater proportion of brick pavements laid up to 1895 were filled in the joints with sand or bituminous material. For many years they were laid on natural foundations. Artificial bases had their inception in the belief that thus imperfectly drained or consolidated subgrades might be bridged over and settlements in weak spots prevented. The cushion or bedding beneath the brick primarily was intended to compensate for unevenness in the surface of the base. Sand and bituminous fillers continued to be used after the construction of artificial bases became general.

With fillers of these kinds, chief reliance for the durability of the pavement as a whole was placed in the wearing qualities of the individual service-unit. That confidence was not misplaced is evidenced by the very large numbers of brick pavements more than 25 years old that are still doing duty with and without artificial bases. Parenthetically it may be said that those pavements which were originally sand-filled are among the best of these. At the time of which we are speaking there had not been developed a bituminous filler that could meet the much-specified requirement that "it shall not flow in hot weather nor become brittle in cold weather." The result was that as soon as the filler had left the joints, the edges of the brick cobbled. Pavements then became noisy, naturally enough, when traversed by iron tired vehicles. Nor could the open joints be justified in view of the increasing demand for clean streets since open joints collected so much pavement refuse.

The development of cement-grout-filled brick pavements grew out of these conditions. The hard filler it was thought would protect the edges of the brick. Cobbling under traffic would be prevented and at the same time a surface of 100% sanitary value provided. Moreover, it was believed that the firm bonding of each brick to its neighbor would furnish a monolithic wearing surface reflecting *all the inherent service-value of the individual brick composing it.* Just as the sand cushion had been used with sand and bituminous fillers it was continued in use with the cement grout filler.

Many millions of square yards of brick pavements on the sand cushion were built in the period from 1895 to 1915. This type came to be regarded as the all but universal kind of brick pavement to be built in the East, the South and throughout Ohio, Indiana and Illinois. This district was each year a larger user of brick for paving. Engineers sincerely believed that the cement grout filled brick pavement was the solution of most of their problems.

Furthermore, it is apparent that this opinon could not have been wholly without a foundation of fact. The type could not have been utterly unjustified. Had it been, brick could not have gained the favor it has in the public mind if its service behavior had been altogether lacking. Nor could the paving brick industry have had the strong and vigorous growth that came to it during that period.

It became increasingly apparent, however, in observing this type in service as built under average working conditions, that the sand cushion was a tricky and dangerous element of the structure. Uniform compression was the exception rather than the rule. In all too many cases patches of the surface have been broken down. The brick have given every appearance of being crushed under traffic. In fact, in the minds of many, the cause was attributed to defective brick. It was soon discovered, however, that the real cause was in an imperfectly compacted sand cushion. The sand would be forced into the joints from below when the surface was rolled. The filler could enter the joint (in many cases) only a fraction of an inch. A force was therefore exerted upon a fraction of the face of the brick, and the worst situated fraction at that, which snapped off the entire tops of the brick.

This type, possible to be built satisfactorily with the use of care and thorough supervision, was finally found inadvisable for further use. The hazard was too great. It was satisfactory neither to the public nor to engineers who had sponsered it nor to the paving brick industry.

The solution seemed to be found in the development in 1914 of the green concrete foundation type and the semi-monolithic type of brick pavement. If you will consult the literature of the period from 1914 to 1916 you will find constantly reiterated belief that the principal merit of the two types lay in the elimination of the hazard of the sand cushion. That belief has been justified in the facts.

It has also been proved, as was predicted at that time, that while longitudinal cracking common to the sand cushion type in frost latitudes, while not altogether eliminated, has been reduced. Entirely to do away with these cracks in slab pavements is a "consummation devoutly to be desired," and must await a more perfect knowledge of soil and drainage conditions and a better understanding

of internal stress and strains in monolithic pavement structures. Even with a development of this phase of pavement construction many times more thorough than at present, it still must be proved that subgrade drainage is a cure-all rather than an aid for the prevention of slab pavement cracking or concrete base cracking.

It was further believed of the monolithic and semi-monolithic types that the unit structure created by the intimate union of base and wearing surface would bring about increased stability, hand in hand with economy in design, as compared with the sand cushion type. For a variety of reasons that will be discussed later it is already apparent that possible economy in design has not been taken advantage of by engineers to the extent that it is available. In fact, in some localities the opposite is true. But more of that later.

You will recall at this point that so far the discussion has been confined to the section of the country East of the Mississippi river. What of the West? What of the portion of the country that undertook its paving improvements outside the largest centers of population, considerably later than East of the river?

In its early brick pavements the West somewhat naturally followed Eastern precedent and used the bituminous fillers or sand to a large extent. Being in the field of asphaltic oil production it naturally turned to asphalt filler as the principal one. On account of its being a native product there was every reason for developing it to the highest possible point of efficiency. For many years the progress attained did not justify too optimistic hopes that fillers would be produced superior to those that have already been described as to behavior. But there is this marked difference in the course which paving practice followed. Where the East turned from bituminous to cement grout filler, the West persevered in its endeavor to improve its asphaltic filler. And finally success came.

Fillers produced showed increasing stability under high temperatures and less brittleness under low. And about 1912 it could definitely be stated that a filler had been found that would not flow in hot weather nor chip out of the joints from brittleness in cold weather. It would remain in the joints with apparently no loss of vitality that could be discovered over a period of years. It did afford the desired protection to the edges of the brick. It met the requirements for quietness and sanitation. Minor readjustments of the surface of the pavement are not followed by harmful disturbances as is true with hard filler.

This filler has been improved still more since 1912 and in its improved form has been adopted in the asphalt filler specifications of the National Paving Brick Manufacturers Association and also by the Asphalt Association. We shall discuss it at greater length a little later. We are getting to the close of our review, which would not be complete, however, without some reference to the changes undergone by the brick themselves in the period from 1895 to that we are discussing.

Prior to 1895 nearly all brick laid measured 2¼x4x8 to 9 ins. They were plain wire-cut and unrepressed. They were thoroughly well vitrified brick; so much so that they were sometimes somewhat irregular in shape. But they did possess beyond question unequaled wearing qualities. They were very tough and very hard. It was at about this time that agitation began among engineers for a brick of more perfect shape. The response of the paving brick industry was the brick of the so-called block size—3½x4x8½ ins. The 3½-in. width was selected on account of certain alleged convenience in affording the grip for the calks on horses shoes. It is a well established fact that no scientific principle, either from the manufacturers' standpoint or the engineers', led to the adoption of the 3½x4x8½-in. size.

Coincidentally with the making of the block size came the addition of projections or lugs for spacing. The plain wire-cut brick had done their own spacing. With the extreme regularity that was expected with repressed brick the lugs were deemed necessary. With perhaps equal weight the argument for foothold for animals was advanced as an additional reason. The fact that cement grout filler had come into use did not have a great deal of influence as far as lugs were concerned until engineers began to use the coarse grades of sand in the grout. It is also true the rounded edge of repressed brick assisted rather than otherwise, the entrance of sand cushion into the joints from below.

Older engineers who were laying brick at this time will confirm the fact that cement grout filler was used with the plain wire-cut brick without difficulty. There are too many of these old streets still in use in this very section of the country to speak other than in the affirmative on this point.

Once the block size of brick began to be made by practically all manufacturers, there was practically no change in the size or shape of brick until in 1910 there was developed west of the river the wire-cut brick 3x4x8½ ins. in size, having two instead of four lugs formed by the die instead of being repressed.

Also, there were produced East of the river, contemporaneously, wire-cut-lug brick that aimed to recognize the demand for the advantages of wire-cut as against repressed brick. In size no change was made from that of the repressed brick. Edges of this and the wire-cut brick West of the river were square, whereas, repressed brick were round-edged.

Wire-cut-lug brick and the vertical fiber brick (both trade names) had lugs. In the first case they have been retained; in the latter case engineers by 1917 had become convinced that the lugs were superfluous. This point of view is spreading rapidly among engineers and the public and to meet the new conditions the National Paving Brick Manufacturers Association has adopted the 3x4x8½ brick as its standard product.

III Modern Conditions

Earlier in this paper we discussed the fact that no longer can it be said that there is a universal type of brick or other pavement. Let us analyse this statement and see if it is tenable. Let us make comparisons with other lines of engineering work.

Do we use standard footings for all columns in high building construction? Do we use standard designs for every bridge pier; for all dams; for each retaining wall?

The answer of course is " no?" Yet these are comparable departments of engineering. Each of these structures is called upon to support loads and each rests upon whatever soil foundation is available in each case. We must bear in mind also that each of these is a localized

structure with a minimum expectation of variation in subsoil beneath it. Yet we very well know that subsoil and also surface soils vary noticeably within short distances.

In spite of the precedent for individual designing thus established for structures resting upon the earth, it has been ignored to a great extent in road construction. Engineers have not insisted with that energy with which sound principles should be supported, that subsoil and surface drainage should be made as perfect as possible.

Drainage has been neglected to the point of being ignored. Coupled with the known fact that soils vary within short distances and the saturated subsoils afford little if any bearing value for the pavement structure, we have blindly gone ahead and required the construction of "Standard" types of pavement without regard to these conditions. It is not unusual that the same kind and depth of base will be specified for a road 12 miles long. If the section is adequate for the worst condition then it is extravagantly designed for every other condition.

Extravagance is not compatible with sound engineering. Because in one locality a brick pavement, for example, has been built on a 4 in. concrete base is not justification universally for that depth. Conversely, it does not follow that because a 6 in. base seems to be needed in one place that the same depth is required a mile away.

The time is coming, and it is not far distant, when a single stretch of pavement will be designed in 100 ft. sections. In a given contract for a single road there may be concrete base, rolled stone, gravel or slag base; each one may be anywhere from 4 ins. upward in depth. And if we carry the thought to its logical conclusion there may be portions requiring no artificial base.

Individually designed roads are a necessity. The use of blanket types is wasteful. It ignores the fundamental principles upon which the character of the profession's public service is founded. It cannot endure.

Clearly the practice of standard sections of pavement is the outgrowth of ignorance of the fundamental laws of pavement design. Not knowing the facts, we design blindly. If all the money that has been wasted in standard section could have been spent in research to discover these laws we should long since have been on the high-road to real economy in pavement construction and use. As it is we are aimed in the opposite direction.

The very ignorance in which we work is responsible also for ill-considered pronouncements of theory that have no foundation in proved facts. It is nothing new to recall that the virtue of a conclusion rests upon the initial premise. It is quite possible to make assumptions that will yield any desired result in subsequent analysis. The verity of the result lies not in the conclusion, but in the underlying facts. Fundamental laws of mechanics, unfortunately, do not disclose error when assumptions are made that can yield but one conclusion, and that one predetermined.

No better illustration of the fact can be cited than the alleged beam theory of pavements. It is very well known among students of mechanics—presumably a proper synonym for engineers—that the simple beam theory applies to an unsupported span on fixed supports at each end—the ends of the beam being free to move. If the argument is advanced, as it frequently is, that a comparable condition exists in the bridging of a trench, then the theory as applied to pavement falls to the ground because the ends are not free to move.

As nearly correct a description of a slab pavement as we can now write is this: It is a continuous slab resting upon a continuous support of varying elasticity, to be designed to carry moving loads. As yet we do not have a proved analysis of such a structure. The nearest approach to it will be found in the analysis of rail stresses, and as far as this work has proceeded it is based upon results secured by the use of an extensometer under actual service conditions.

It will also be recalled that the simple beam theory is based upon positive bending moments. There are no negative moments in a simple beam. The moment beam or slab continuity is introduced, however, you have set up a consideration of negative moments. Under moving loads a negative moment moves in advance and in rear of the load, and is effective in the vicinity of the support. Witness the analysis of continuous beams on fixed supports. Just what happens on elastic supports is yet to be shown.

Admittedly this discussion is theoretical; admittedly, also, sufficient points have been raised to discredit the simple beam theory as applied to slab pavements. But fortunately we have recent data presented by the Office of Public Roads, derived from the measurement of the effect of motor trucks upon pavement surfaces, to show that the principal force of traffic to be met is impact and not bending. Surely engineers will not longer, in justice to the standards of the profession, continue in the path of the beam theory. Its fallacy is too evident.

What, then, can we do while awaiting the production of scientifically determined data that can be used with the backing of proof? The answer to that question is clear. We should return to first principles. We should place ourselves upon the safe ground of minimum hazard.

In the end that means the abandonment of cement grout filler as far as brick pavements are concerned. It means that in many cases concrete bases will be supplanted by another type—the rolled base. It means the passing of standard cross-sections of pavements of all types. And these things mean laying the foundation of real economical pavement design.

The coming of a saner period of pavement design is evident. Already the reaction against slab pavements is setting in and the rolled base is in the ascendency. And we should not forget that there is more than one type of rolled base. Some are water-bound, some tar-bound, some bound with dry screenings. Local stone secured by the roadside is adequate. The keynote of this type, as it should be of all types of base, is sufficient serviceability at minimum cost.

Durable wearing surfaces on bases meeting this criterion mean economical pavements.

IV. Specifications

The forthcoming specifications of the National Paving Brick Manufacturers' Association will recognize the principles that have been discussed in this paper. The specifications will be specifications of details. There will be a concrete, rolled stone, gravel and slag base bound with screenings and with tar. There will be asphalt filler and alternates of sand, cement grout, and combined tar and asphalt fillers. The sand cushion will be specified to accompany bituminous and sand filler, the cement-sand bed

or the green concrete base where cement grout filler is used. The specifications will be published in sections. By proper selection a type of brick pavement can be specified that will meet local conditions with economy.

In response to a well-defined and growing demand on the part of engineers and the public for stabilizing the character of its product, the National Paving Brick Manufacturers' Association has adopted the 3x4x8½-in. square-edged brick without lugs as its standard. Already the demand has brought about the exclusive manufacture of this brick by a large portion of the industry, and as rapidly as the market for this brick requires it, production will be increased. If it grows at the rate now evident, it will be but a short time before variety in brick types will be a thing of the past. The sooner this occurs, so much the sooner will engineering progress of real worth be made. The element of the wearing surface will become stabilized, permitting such variation in bases as is needed the best to meet a given condition.

Summary

To sum up the base of brick pavements at the beginning of 1920, we may state these points as clearly defined:

1. The value of thorough subsoil drainage is becoming realized.
2. The use of a variety of kinds of bases to meet different subsoil, traffic and economic conditions is established firmly.
3. The tendency of design is away from the slab types of brick pavements and toward the types that depend upon the high quality of the individual unit as against the monolithic surface.
4. The use of cement grout filler is on the wane.
5. The coming year will see the widespread adoption of the standard brick in localities now laying numerous varieties of lug brick.

Acknowledgment

The foregoing paper by Mr. Greenough was presented before the Illinois Society of Engineers at the 1920 annual convention.

IMPROVING SEWAGE PLANT OPERATION

By C. H. Currie, Civil and Sanitary Engineer, Webster City, Iowa

Improving poor operation of sewage treatment plants in average and small communities is probably the most vital problem confronting Public Health Officials and Sanitary Engineers. This is true in the State of Iowa and in the neighboring states and is undoubtedly true in other places. But the writer, being more familiar with sewage treatment plants in the State of Iowa, will confine this article to that state.

Why Some Sewage Plants are Neglected

Sewage treatment plants are comparatively new and, especially in small places, they almost universally lack appreciation and care, which might naturally be expected. Fundamentally, the ideal way of insuring proper operation of sewage treatment plants and the consequent safety of the effluent, would be to have all in a community understand and appreciate the importance of this subject, as well as do our State Boards of Health. The engineers, as a class, may oftentimes be rightly accused of criminal modesty in not securing all possible publicity of an educational nature for such a municipal project.

Turning Public Prejudice Into Public Pride

In the writer's opinion, one of the first things to be done in turning public prejudice into public pride on a subject of this kind is to improve the general neighborhood and surroundings of such a plant. Second, make the structures more pleasing in appearance. Third, maintain the plant and grounds surrounding it so as to make it attractive, instead of permitting it to assume the appearance of a dumping ground or similar eyesore.

Many communities are failing to protect themselves properly and their neighbors by not installing sewage treatment plants because of the impressions they have formed from viewing plants in neighboring towns which have fallen into a state of poor repair and consequent ill repute. In many towns and cities in Iowa under 3,000 population, such a deporable condition does exist, as is

VIEWS OF TWO SEWAGE TREATMENT PLANTS IN IOWA.

Upper View: Housed filters at New Hampton in foreground. Housed Imhoff tanks at rear. Nearest dwelling house about 500 feet from plant, but houses will eventually adjoin plat where plant is located.

Lower View: Neglected sewage filter at West Liberty. This plant is remote from residences and its remote location leads to its neglect.

evidenced by the results of examinations by the State Board of Health. Unfortunately the State Board of Health of Iowa does not have sufficient funds appropriated for this purpose, so that they can make the necessary visits to every community having treatment plants and keep the officials of that community alive to the necessity of proper operation, as this would be of material assistance in improving the conditions existing at present.

Influence of Location on Care of Plant

Many of the former treatment plants were constructed, some through necessity and some through intent, in inaccessible places and near disreputable surroundings, such as dumping grounds, slaughter-houses, etc. In such surroundings one can scarcely expect that much civic pride will be expended upon proper care and operation of sewage treatment plants, and it will be pretty hard through

any method of publicity to overcome the prejudice of a community having such a condition existing. The easiest method would be to clean up the neighborhood, the surroundings, and the plant itself, make it accessible and keep it in good condition.

Value of Superstructures of Good Appearance

Since 1912 more sewage treatment tanks in the State of Iowa have been constructed with superstructures of

VIEWS OF THE SEWAGE TREATMENT PLANT AT MASON CITY, IOWA.

Upper View: Housed Imhoff tanks, dwelling houses are less than a block away. Lower View: Covered trickling filters.

pleasing external appearance, more care has been given in cleaning up and leveling of the grounds surrounding the tank and the filters, and in some instances some attempt has been made at modest landscaping. While possibly a few such plants have been neglected, a comparison of the relative efficiencies of such plants, where well located and kept up with plants not so fortunately located and constructed, is an indisputable argument in favor of the former.

Two Examples

The writer was very strongly impressed with this the past summer in visiting two towns of about 1,000 population each, within 30 miles of each other, one of which had built its treatment plant eight or ten years ago, the other one about three years ago. One of the officials reluctantly accompanied him to look over the first treatment plant and the conditions found were as follows: The tank was of the old type with the slab cover at ground level, and the citizens, owning the ground surrounding this and thinking of no other good location, had for some few years past been using it as a public dumping ground, so that refuse and garbage had piled up until it covered a part of the settling tank. The filter beds were faintly defined by the relative height of weeds and naturally the effluent from this tank was little better than raw sewage. Upon inquiry, the official advised the writer that they had received letters from the State Board of Health urging them to look after their sewage treatment plant, but found it hard to get a man to look after it, that the fellow who did know how had left town and no one seemed to kick on the effluent, except a short time in the summer, so that they did not feel like spending much money on it. He was of the opinion that the tank was no good and that they might need a new one. The writer was unable to secure a full set of plans, but, from what he saw, is of the opinion that the plant was well designed and if proper care had been given, it would be affording a safe effluent today.

The other town visited had a well located plant, easily accessible from public highways, with a pleasing superstructure. In company with one of the officials we went over this plant very carefully, and the writer was particularly impressed with the attitude of this official, and other citizens whom he visited with later, who instead of being ashamed of such a plant, all seemed somewhat familiar with the general principles involved in the purification of sewage, and considered this plant one of their chief assets.

One banker remarked that he had taken visitors there, which was one place he had never imagined could be a point of interest and pride, before seeing their plant. Such an attitude almost guarantees this town future successful operation, as they have employed an engineer to visit them and advise their operator whenever necessary.

The few pictures of different plants, shown herewith, while not taken with this subject in mind, will serve to illustrate the points covered.

Comparatively few plant operators have ever seen their tanks empty and probably do not have a mental picture of the entire structure and are doing their work or part of it in a "rule of thumb manner." It is suggested that a well-framed set of instructions, simple and shortly worded, indicating the things most vital in the care of the different units of a treatment plant, together with isometric drawings showing the construction of the entire plant and the important things requiring attention will prove of great aid to the operator and insure more intelligent care with consequent better results.

FUNDAMENTAL CONSIDERATIONS AFFECTING CONCRETE PAVEMENT DESIGN

By S. T. Morse, City Engineer, Carlinville, Ill.

The recent large expansion in the use of concrete for constructing the modern highway renders it highly important that paving engineers thoroughly understand the structural laws and natural conditions affecting the proper design of such roadways. It is to be conceded that the past status of the science has not, as yet, provided generally recognized rules for the guidance of engineers in designing the thickness and form of their pavements. Each engineer, usually, has provided an edge and central thickness based on his particular experience or judgment, and thus the spectacle is presented of some highway departments using an edge thickness of 6 ins., others of 7 or 8 ins., while some use a central thickness of 7 ins. and others up to 10 ins. It therefore seems advisable that generally accepted standards be determined and adopted; for, at the present price of 30 cts. per inch of thickness per square yard, the paving engineer, who can without structural failure, by his application of correct methods of design, reduce the specified thickness of a mile of concrete pavement 1 in. has earned his salary for one year. Contrariwise, if through a lack of such knowledge, and a

desire to construct cheaply, the pavement section is constructed too light, the public has lost much more in maintenance costs and early reconstruction. Therefore with more than $600,000,000 to be expended for roadways in the immediate future, the correct design of concrete pavements has become a question which should at once be placed on a recognized and correct scientific basis.

Design of Form

In developing the true method of designing the slab of a concrete pavement, the active external forces must be carefully determined, and the forces of resistance be made equal thereto.

The fundamental considerations which mainly affect the rational determination of the thickness and form of a concrete pavement are as follows:

First—The nature of the foundation, whether it be of muck, clay or sand, whether in a dry, moist, saturated, or frozen condition.

Second—The nature, speed, and weight of the moving loads which are likely to pass over the pavement, which includes the nature of the tires and springs.

Third—The strength of the concrete to be used, which includes a knowledge of the mixture, the character of aggregate, the amount of water used, time of mixing, and the age at time of first major test.

Fourth—The width of the pavement under consideration.

In the light of the present knowledge of the subject, the effect ot each of the first three factors may now be determined within rather narrow limits, and the fourth factor is always a known quantity. A brief discussion of the four conditions and their probable effect on the design will now be given:

The Foundation

First—On the nature of the foundation, whether of clay or of sand, whether wet or dry depends the amount of vertical motion transmitted to the edges of the pavement by the freezing of the earth beneath the edges. For more complete details of the action of this factor see articles by the writer on concrete pavement construction in Eng. & Cont'g. of July 9, 1913, and Feb. 7, 1917. It has been definitely shown by Mr. J. W. Lowell, see Eng. & Cont'g. Nov. 6, 1918, that "The vertical movement or heaving naturally is greatest at the sides where moisture is a maximum and decreases toward the center." It was further shown that the vertical motion of a clay subgrade may equal 7/16 in., and was found to be much less on a sandy subgrade.

Concrete slabs deflect with the movements of the sub-grade if their stiffness is not sufficient to carry their weight, and, if the deflection becomes great enough, a crack develops along the line of greatest stress, a structural failure is the result.

The writer has observed the upheaval of pavement edges due to frost, to be as much as ¾ in. The point or line of application of the summation of these upward or reacting forces becomes the point or line of support for each side of the slab. These lines of support are located at some distance from the edges toward the center of the pavement, and the distance varies with conditions of the weather, and the wetness and character of the subsoil. The distance of the line of support from the center of the slab, being a variable, may be denoted by x, a factor of the span or width of pavement. No definite determination of the extreme location of these lines of support has, as yet, been made, but the maximum stress in a slab is obtained when these lines of reaction approach nearest the edges of the pavement; through a period of 7 years of close observation of this feature, the writer is convinced that these lines of support at times approach very near to the edge of the pavement where the slab is stiff and strong enough to sustain itself, and in this discussion x will be given a maximum value of 0.95 which is considered safe and representative of the facts.

Weight and Speed of Moving Loads

Second—The weight and speed of moving loads which the pavement is expected to support has an effect in stressing the slab second in amount only to that caused by the dead weight of the slab; in fact, it may be shown by the equation hereinafter proposed that a wheel load of 5 tons multiplied by a shock factor of 4 may cause as much stress in slabs 15 ft. in width as does the dead load under maximum conditions, and that the moving load becomes the major factor in more narrow slabs.

It has been theoretically demonstrated by Mr. J. W. Pearl, see Eng. & Cont'g. Feb. 11, 1914, that a concentrated load on a concrete slab is distributed over a circular area which has for its diameter, approximately, the width of the slab, within certain limits, and that the bending moment

$$M = \frac{Pr}{4},$$

equating to the resisting moment

$$\frac{Pr}{4} = \frac{2\,\Pi r f t^2}{6},$$

from which equation No. 1 is

$$t^2 = \frac{P}{4f},$$

where t is the thickness of the slab, P the load, and f the unit stress.

For further discussion of the effect of static loads on slabs, see article by Mr. E. B. McCormick before the 11th Annual Convention of the American Concrete Institute, Feb. 9, 1915, and Bulletin No. 28 of the Ohio State Highway Department.

In equation No. 1, there is no provision made for including the effect of shock which arises from moving loads. The amount of shock depends on the weight, the speed, roughness of the road surface, kind of tires, and the springs, and in all previous efforts to evolve a correct equation expressing thickness the writer, and no doubt others, have been hindered by this unknown shock quantity which may be represented by the symbol y, and equation No. 1 becomes

$$t^2 = \frac{yP}{4f}, \quad (2).$$

The U. S. Bureau of Public Roads has recently been making these much needed impact experiments, and while a full report is very difficult, if not impossible to obtain, the important results have been reported by Mr. A. T. Goldbeck, its Testing Engineer, in a paper abstracted in Eng. & Cont'g. Dec. 3, 1919. Quoting from this paper,

"The indications are that when a wheel load of 8,500 lbs. is at rest on an 8-in. concrete slab laid on a rather wet subgrade the fibre stress in tension is only about 34 lbs. per square inch directly over the load." Substituting the above known quantities in equation No. 1 and solving for the real value of f in said equation, we find that

$$8^2 = \frac{8{,}500}{z34}, \text{ or } z = 3.9$$

which is a very practical verification of the theoretical value 4, and with this verified value of the factor of f further investigation may proceed with confidence.

In his paper Mr. Goldbeck stated that "The highest pressure thus far measured being in the neighborhood of 42,000 lbs. when the weight on the rear wheel causing this pressure was only 7,750 lbs. The unsprung weight on one rear wheel of this truck was 1,837 lbs." This pressure was very exceptional, and the experiments show, in general, that the maximum pressure caused by impact was about four times the static weight of the wheel load, from which a fair value of the factor y may be placed at 4. Using the highest pressure found, viz. 42,000 lbs., under the conditions named the unit stress developed could not exceed about 165 lbs. per square inch, from which it must be conceded that the moving load is but one of the rather minor factors affecting the design of concrete pavements.

Strength of the Concrete

Third—The third fundamental affecting road design has to do with the resisting moment of the slab itself. The resisting strength of a concrete slab is controlled, mainly, by the relative amount of cement used, the grading and quality of the aggregate, the amount of water, the time of mixing, and the age of the slab at the time of stressing. A short consideration in detail of these factors will be given following the discussion of the form design.

Quoting again from Mr. Goldbeck's recent paper "The modulus of rupture of the ordinary concrete road mixture is well over 400 lbs. per square inch, and possibly as much as 600 lbs. per square inch." These values of f are substantiated by tests of Prof. A. N. Talbot, and by tables of Taylor and Thompson; so that with a concrete mixture of 1-1½-3, a conservative value for f may be assigned at 400 lbs. Also, with a mixture of 1-1-2, according to all available tests, it is quite as conservative to assign a value of 500 lbs., to f, the modulus of rupture, which leads at once to the very interesting conclusion that a concrete pavement of equal strength may be designed as cheaply with a mixture of 1-1-2 as one of 1-1½-3, and, according to the recent tests, of Prof. D. A. Abrams, the abrasive resistance increases as the strength of concrete increases which indicates that at least 30 per cent. more wear may be expected from the richer mix at the same cost. This idea is injected for future consideration, and it is hoped, will not cloud the issue directly in hand.

Width of Pavement

Fourth—The width of the pavement has a most important bearing on the road design in that it is properly the span of the beam considered, and by the laws of flexure enters the problem as its square; the equation for the moment of a simple beam being

$$M = \frac{w(x12L)^2}{8},$$

in which w equals the weight per square unit $= \frac{t}{12}$, and L equals the width of the pavement in feet. Equating to the resisting moment,

$$\frac{12t\,(xL)^2}{8} = \frac{fbt^2}{6}, \text{ from which } t^2 = \frac{9t(xL)^2}{f}, \quad (3).$$

Equation (3) indicates that the thickness of concrete pavements must be increased as the square of the width increases, nearly. Since the present tendency is to increase the width of roadways to a minimum of at least 20 ft. for all double traffic roads, it is very evident that accurate knowledge of the design necessary to fulfill the structural requirements should be at once at hand to the end that the $600,000,000 available for immediate construction may be expended without undue structural failure, and with the full assurance that there is not material waste by uneconomical design of form and thickness. Quoting Mr. Goldbeck "In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or too little initial expenditure for our various road systems." We must not be satisfied with a constant cross-section irrespective of the fundamentals affecting road design.

Having considered in the above discussion the fundamental conditions which affect the design of concrete road slabs, a fundamental formula for the rational design of concrete slabs placed on shallow, unstable foundations may be derived.

Since the bending moments are proportional to the square of the thickness of the slabs equations (2) and (3) may be combined and

$$t^2 = \frac{9t(xL)^2}{f} + \frac{yP}{4f}, \quad (4).$$

from which the general formula is obtained,

$$t = \frac{4.5(xL)^2}{f} + \sqrt{\frac{yP}{4f} + \frac{20(xL)^4}{f^2}}, \quad (5)$$

Ascribing to x the value 0.95, and to y the value 4 as determined in the above discussion,

$$t = \frac{4L^2}{f} + \sqrt{\frac{P}{f} + \frac{16L^4}{f^2}}, \quad (6)$$

which, using f = 400 with a concrete mixture of 1-1½-3, becomes

$$t = \frac{L^2}{100} + \sqrt{\frac{P}{400} + \frac{L^4}{10{,}000}}, \quad (7)$$

and using f = 500 with a concrete mixture of 1-1-2, equation (5) becomes

$$t = \frac{4L^2}{500} + \sqrt{\frac{P}{500} + \frac{16L^4}{250{,}000}}, \quad (8)$$

The writer presents general equation No. 5 to the paving world for guidance in the rational design of

the central thickness of concrete pavement slabs with entire confidence that it will be found correct in form, convenient to use, and that it will provide safe weights within the assumed conditions of service. The thicknesses given will prove to be slightly excessive for pavements built on sandy foundations which will give opportunity for the exercise of good judgment, guided by the formula.

As an illustration of the value and applicability of a rational, recognized method of designing slabs, consider the concrete road being built from Mt. Clemens to Detroit which is reported to be 8 miles in length, 24 ft. in width and 10 ins. in thickness, applying equation (4), it is found that, with a clay subgrade, the unit stress as planned may run as high as 560 lbs. per square inch which is too high for most concretes, and unless all of the foundation is quite sandy, a number of structural longitudinal failures are likely to occur which will require considerable maintenance expense. Either the central thickness should be increased to 12 ins., or better, two parallel, adjoining slabs 12 ft. in width may be constructed with a uniform thickness of 7 ins., which on this road, estimating the cost at 30 cts. per inch of thickness per square yard, will save in first cost $12,000 per mile, or a total of $96,000 on the job. If 10 per cent. of the amount saved be placed at 5 per cent. interest it will return $60 per year per mile as a maintenance fund which is much more than well built concrete roads have been costing to maintain. There are many extravagant examples of this character. It seems important that a recognized system of design should be generally adopted. The writer has eliminated the longitudinal crack from pavements of his construction.

Design of Mixtures

The quality of materials, their proportions, the grading of the aggregate, the amount of water, the time of mixing determine to a large extent the strength and abrasive resistance of the road.

Cement—Considerable difference still is found in the fineness, strength and soundness of the various brands of cement. The quality should meet the requirements of the A. S. T. M. standards. The writer requires a tensile strength of 700 lbs. per square inch 28 days after mixing. The care and expense incurred in procuring the best of other materials and proper workmanship must not be discounted by the use of poor cement.

According to all available tests, there is a very marked increase in the strength and durability of a concrete having a mixture of 1-1-2, over one having a mixture of 1-1½-3, amounting, approximately to 40 per cent. additional strength with about 37 per cent. more cement. The modulus of rupture and the abrasive resistance appear to be likewise increased. With an increased knowledge of the design of pavements, the writer has the temerity to suggest that within the near future, the first-class roads will be constructed with a mix of 1-1-2, and at no greater cost per square yard.

Aggregate—The grading of the aggregate should be made the subject of much consideration. The fund of information concerning the correct grading has, recently, been much increased by the many tests made by Prof. D. A. Abrams of the Lewis Institute, Chicago, who has clearly defined and uses what he terms the "Fineness Modulus" as the standard guide for determining the correct grading of the aggregate. The writer finds this method easily workable, and definite in its results. In preparing specifications, it seems advisable to provide a definite proportion, such as 1-2-3 with the added clause, "Except that when the 'Fineness Modulus' as defined by Prof. D. A. Abrams in Bulletin No. 1 of the Structural Materials Research Laboratory, Lewis Institute, shall be less than 5.5 then the above specified two parts of sand shall be reduced in quantity, and when the said 'Fineness Modulus' shall exceed 6.0, then the amount of sand used shall be increased in excess of the specified two parts." Such a specification provides a definite basis for making estimates of cost and quantities, and a definite system for properly grading the aggregate; it requires that the Engineer in charge shall have and use frequently a set of standard sieves, which each paving engineer should possess.

Water—By his many tests, Prof. Abrams has also proved the first importance of holding the amount of water used, relatively to the amount of cement used, at the lowest possible point which will provide a workable mixture. He has shown that by decreasing the water used in mixing from an amount of 100 per cent. to an amount of 85 per cent. of the quantity of cement used, the strength of the resulting concrete is increased as much as 25 per cent. Hence, if the modulus of rupture "Of the ordinary concrete road mixture," as stated by Mr. Goldbeck, is as much as 400 lbs., then the modulus of rupture of a concrete mixed with the correct amount of water would be at least 25 per cent. more or 500 lbs., and applying equation (6) for required thickness for a road 16 ft. in width, we find, using the dryer mixture, that the required thickness is 7.05 ins. as against 8.17 ins. for the ordinary wet mix, or a real saving of 1.12 ins. in thickness of concrete, whch at 30 cts. per inch per square yard will save $3,150 per mile of road 16 ft. wide. It is to be conceded that the dry mixture requires more labor and time in construction, but the above amount of saving will pay the contractor for considerable time and trouble, and also provide for considerable added inspection, moreover ways and methods will speedily be found to reduce the added cost of the dry mix to a negligible quantity. The above determination is but another illustration of the advantage of having for use a formula and recognized system of design for concrete roads.

Such tests as those made at the Lewis Institute are welcomed by all engineers, and certainly great credit is due Prof. Abrams.

The above stated methods of design will provide a concrete pavement with sufficient central thickness and strength to prevent the central longitudinal cracking, so frequently observed, and will also assist designers in

TABLE I—SHOWING THE REQUIRED THICKNESS AND RELATIVE COST PER SQUARE YARD OF WIDE AND NARROW PAVEMENTS. P = 10,000 LBS.

Concrete Mixture Cement, Sand Stone	Estimated Cost per Inch per Sq. Yd. cents	Road Width 10 Ft. Thickness Required t (ins.)	Road Width 10 Ft. Cost per Sq. Yd.	Road Width 12 Ft. Thickness Required t (ins.)	Road Width 12 Ft. Cost per Sq. Yd.	Road Width 16 Ft. Thickness Required t (ins.)	Road Width 16 Ft. Cost per Sq. Yd.	Road Width 20 Ft. Thickness Required t (ins.)	Road Width 20 Ft. Cost per Sq. Yd.
1-1½-3	30	6.1	$1.83	6.64	$1.99	8.17	$2.45	10.4	$3.12
1-1-2	35	5.34	$1.86	5.78	$2.02	7.05	$2.47	8.22	$2.88

avoiding extravagant and excessive central thickness toward which the tendency now is.

There yet remain for discussion and solution, the questions of edge thickness, and the elimination of transverse cracks. It may ultimately be determined that the forces which produce the majority of transverse cracks are also the forces which will govern the required thickness of the slab at its edges. The writer is investigating this phase of the subject in particular, and has made at least one unexpected and interesting discovery. Experiments, looking toward the entire elimination of transverse cracks, also, are in progress, but results will not be available for another season.

It will be a cause for much satisfaction among paving engineers, certainly, if it may soon prove to be that concrete pavement slabs may be economically constructed with full assurance that they will not structurally fail.

THE PROPER WIDTH OF A PERMANENTLY PAVED HIGHWAY

By Monroe L. Patzig, Consulting Engineer, 418 Kraft Bldg., Des Moines, Iowa

To me durable highways **must** be Travel Safe. If not they are not durable because they will sooner or later have to be made safe. Have not the railroads had to inaugurate safety devices and adopt safety methods of construction?

Observation on a Highway

The writer has for almost a year observed the condition of travel on a certain highway to one of our cantonments located 12 miles from the city. The traffic on this highway was considerable, but no greater than the same highway will be compelled to handle at certain occasions when it is linked up with other highways. Evidences of new accidents were observed on every one of the numerous trips made over this highway. In mentioning this fact to the Major in charge of Building and Construction the writer was surprised to hear him make the statement, that there was an average of an accident each day.

The climax, however, came a little later when the writer discussed the matter of widths of highways with one who was interested in highway construction. His belief was that 12 ft. pavements would be amply wide enough in many instances and defended his theory by offering as evidence the practice of some of our eastern states.

A further search for evidence, or rather an excuse for narrow pavements, resulted in finding locations of 10 and 12 ft. widths, but no evidence was found to substantiate the theory that they are safe or economical, excepting in remote communities where there is but occasional traffic.

Views of Others

A few views of others on this matter may be advisable and I am glad to quote Mr. G. Robert Ramsey, Assoc. Member American Soc. C. E., Consulting Engineer, Orlando & Tallahassee, Florida, from an article entitled, "Lessons Taught by Road Building Experience in Florida," and appearing in the February, 1919, issue of Municipal and County Engineering.

"Many miles of brick highway have been built in Florida. Unfortunately many of these roads are only 9 ft. in width. * * * Florida has come to the realization of what her road systems mean to her and the roads that have been built are but the forerunners of what is to come. The road of the future will be better and of sufficient width to permit of the passing of two vehicles."

Also Ray N. Case, County Engineer, Ashtabula County, Jefferson, Ohio, in an article entitled, "The Brick Highways of Ashtabula County, Ohio," in the same issue of Municipal and County Engineering, says:

"In 1915 the first 10 ft. brick roads were constructed. In that year 25 miles were placed under contract. These roads were designed 10 ft. in width, 9 ft. of brick with flush curbs 6 ins. in width and upon 4½-in. gravel concrete foundation, using 1½ in. sand cushion with crown ¼ in. to the foot. This type of road constitutes our greatest mileage, and while some criticise the narrow road, it nevertheless is the highway for rural districts."

He also says "a 16 ft. highway on main roads where there is a heavy automobile traffic would be more desirable."

I also wish to quote Mr. Case in another part of his article because it has a particular bearing on this matter of widths which we are discussing. He says, "No matter how unimportant a roadway be before it is improved, it at once becomes a main highway when improved."

Also in another article which is said to reflect the ideas of the New Jersey Highway Commission the statement is made: "Hard pavements will be not less than 18 ft. wide. In addition there will be 3 ft. stone shoulders on each side, making in effect 24 ft. pavements. There will be 3 ft. earth or gravel shoulders, making a total of 30 ft. of carriage or travel way. On the main, heavily traveled routes are being laid concrete pavements 8 ins. thick at the sides and 10½ ins. thick at the center. On secondary routes are being laid 6 in. concrete pavements at the side and 8½ ins. thick at the center. Where asphaltic brick or stone block pavements are used they will have concrete foundations not less than 6 ins. thick except in the more isolated sections where traffic will not be heavy for many years, asphaltic pavements will be laid upon existing macadam bases, where same exist of proper width and depth. None of the state highways will be paved with macadam or bituminous macadam, or any other material inferior to asphalt or concrete.

"A sincere effort is being made to build for the highway traffic demands of tomorrow. In alignment width, grade and pavement, the viewpoint is that we are building for a long time to come and the best obtainable, within reasonable limits, should be had now."

In no instances has the writer found supporters for the narrow roadway movement making their claims in favor of them without offsetting them by saying they were for light traffic in remote localities only.

Much Traveled Roads Must Be Wide

Are we paving our highways in remote localities or

are we paving them where traffic is greatest and likely to be needed most? This movement is primarily intended to take care of our heaviest and most intense traffic. We don't need pavements in isolated territories excepting in very rare cases, but we do need many miles of them between our principle cities and neighboring towns.

Speed and Clearance

We all know that these highways will be required to handle our heaviest and largest trucks as well as all other sizes and kinds of vehicles. These highways must be designed to carry these loads and to handle them safely. They should safely handle traffic going at the rate of thirty miles per hour. This is the speed limit set by numerous states and seems to be the speed that will be universally accepted. To make this speed less will impair the value of the highway as a rural thoroughfare. To handle traffic at this speed or even at 20 miles per hour will require at least 2 ft. for clearance between the vehicle wheel and the outer edge of the pavement. In observing traffic on highways the writer has observed that this is generally the case. I believe any driver will agree with me that he will not run much closer than this to the edge of the pavement when going at such a rate of speed. Earth shoulders are seldom in such a condition that one can safely allow one wheel to run off of the pavement. To be sure there are places along the highway where this is safe, but it is not likely they will occur where it becomes necessary to pass other vehicles.

This being the case and knowing that we must have even a greater clearance between two vehicles going in opposite directions, it becomes a simple matter to determine a minimum width required. As in the case above, the writer has also observed that 4 ft. makes an average clearance between vehicles.

An average motor car will measure 6 ft. wide overall. We will now add together 4 ft. for clearance at both edges, 12 ft. for two cars and 4 ft. for clearance between them, and we have a total width required of 20 ft.

Having measured trucks which measure 8 ft. in width, the writer does not feel that this width would be unreasonable. Furthermore, some drivers cannot drive as steady as others, and some trucks or cars are not so easily managed as others. Assuming two of these large trucks passing each other we have only a total clearance of 4 ft. or say 1 ft. on each side of the roadway and 2 ft. between trucks.

No Economy in Narrow Roadways

As to economy of the 18 ft. roadway, the writer does not believe that there is any economy. Assuming a price of $4 per square yard for the paving, a 20 ft. roadway would cost about $46,932 per mile, an 18 ft. roadway $42,240 per mile, showing a saving of about $4,692 per mile. This saving will have to be spent on additional care of earth or gravel shoulders and will without doubt be spent in two years time.

As to narrower widths, it may be said they are entirely inadequate, dangerous, and will be expensive to maintain.

Traffic, ordinarily when not confined to one side of the highway on account of passing other vehicles, will distribute itself more evenly over the entire surface of a broad highway than in the case of very narrow roads, where the traffic follows the same line continuously. In the case of 10, 12, 14 ft. roadways this is very readily seen. Marks on the pavement soon show that all vehicles follow the same path. When this path becomes worn it cannot be repaired without causing a great deal of discomfort to the traffic. Under the same traffic the narrow roadway cannot give the same wearing qualities as the two-way traffic road of 18 or 20 ft. width.

While the writer has attempted to show that 20 ft. is not an unreasonable minimum width, there will be many instances where greater widths are important. It is the writer's conclusion that our highways should be paved not less than 20 ft. wide.

THE DESIGN OF PAVEMENT SURFACES FOR MODERN TRAFFIC

By H. J. Fixmer, Division Engineer, Board of Local Improvements, Chicago, Ill.

The design of pavement surfaces for modern traffic is an interesting study and merits more careful attention than is generally given to it. The value of the pavement to the users must be considered of paramount importance. The ideal pavement surface must prove safe and comfortable to use, must be truly economical and present an agreeable appearance. We must consider not only the effect of the traffic on the pavement, but the effect of the pavement surface on the user. We must design our pavement surfaces to fit the needs of the traffic. A pavement is judged by its surface.

Three Classes of Traffic

There are three general classes of traffic, namely, pedestrian, horse-drawn and motor. In some instances one or possibly two classes of traffic may be ignored, but in the typical town or city street all classes must be given due consideration. Since all three classes have a right to use the street, the ideal pavement must be designed to afford each class the maximum of comfort and safety without interfering with the right of comfort and safety of the other two classes. On a given street the relative importance of the various kinds of traffic must be determined. Since horse-drawn traffic is slowly but surely decreasing, less attention need be given to accommodating this traffic. Modern traffic may be considered to consist of pedestrian and motor-driven vehicles.

Provision for Pedestrian Traffic in Chicago

Provision must be made for pedestrian traffic at all street, alley and private driveway crossings. Comfort and safety must be secured. These are secured by eliminating steps as far as possible, avoiding gutter openings in the path of traffic, providing a smooth surface as nearly straight and level as practicable, and keeping the crossing clean and dry.

Considerable study has been given this subject in Chicago in recent years, and it is believed successful, if not ideal, results have been achieved. On streets designed by the writer the usual step from the abutting sidewalk to the pavement surface has been eliminated at all alley, private driveway and street crossings in residence districts.

On business or through traffic streets considerations of safety and the greater importance of vehicle traffic modify the general plan. On all street, alley and driveway crossings along such a street the pavement is built even with the sidewalk for a distance of at least 6 ft. nearest the building line. A step of from 5 to 7 ins. is made at the curb adjoining the cross-walk crossing the busy street. By eliminating the steps along the street the maximum pedestrian traffic is accommodated with little interference with the comfort and safety of the slow-moving cross vehicle traffic. The step at the cross-walk crossing the business street permits the pavement surface to be carried through on a nearly level grade, which accommodates the maximum vehicle traffic. The presence of the step tends to cause the pedestrian to hesitate (and look) before crossing the busy street. Where the street is of unusual width or carries a great volume of fast-moving traffic a safety island is often built. The island is usually 4 ft. wide and 6 ins. above the pavement surface. Where two car line streets intersect, the usual step at the cross-walk is eliminated, since all vehicle traffic must slow down in crossing, and because the large pedestrian traffic at this location demands a comfortable crossing. Where a vehicle is traveling less than 15 miles per hour the slight raise in the pavement surface occasioned by the so-called "flush cross-walk" causes no inconvenience or noticeable jar.

Street Crossings

The importance of a smooth surface at street crossings was early recognized. In the old granite block pavement crossing slabs were laid. In the old macadam pavement brick cross-walks were built. In the typical village or small town the first street improvement generally consists in building a plank, stone or concrete cross-walk. Time has proved them very undesirable, as they soon become uncomfortable and even dangerous to vehicle traffic. Since modern vehicle traffic requires a smooth surface, it is found that a modern pavement agreeable to such traffic is satisfactory to foot traffic.

The crossing should be as level as is consistent with the contour of the pavement and with surface drainage. This means a fairly flat crown.

The crossing should be clean and dry. By reason of paving the crossing even with the sidewalk, with a low crown and slightly increasing the slope of the gutter away from the crossing, the crossing keeps clean and dry automatically. Where a step is necessary it is a refinement worth while to increase the gutter slope across the cross-walk to enable the gutter water to pass without depositing any refuse at the crossing.

Little consideration is now given to horse-drawn traffic in the city except at grades and at localities of heavy trucking. The horse is little used for pleasure driving, and since he travels slow the demands of comfort and safety are of little weight. For horse-drawn traffic the pavement surface should be fairly smooth, non-slipping, and, on all grades and loading areas, afford a good foothold. A resilient surface is recognized as better for the horse, but since he is gradually disappearing from general use it is advisable, as a general rule, to ignore his peculiar needs.

Surfaces for Motor Traffic

Motor traffic, both pleasure and trucking, is the type of vehicle traffic we must design our pavements to meet. Comfort and safety must be secured. The surface should be smooth. It should be of adequate width. It should afford low tractive resistance. It should have a low crown, easy grades, easy turns and an agreeable appearance.

A smooth surface implies freedom from surface irregularities such as appreciable joints and cracks; unevenness due to surface wear or disintegration; unevenness due to debris dropped or accumulated, settlement of the structure underneath, and contour unevenness due to raised crossings, change of grade, and crown slope not adapted to the location. The matter of proper width will not be discussed, except to point out that it is usually determined by the amount of money available rather than a careful analysis of the amount, kind and speed of the traffic expected to use the pavement.

The matter of subsoil drainage, preparation of the subgrade and design of the pavement structure will not be discussed except to point out that these are distinct from the design of pavement surfaces, and that the function of these is to secure and maintain a smooth surface. To have a good surface the pavement must be properly repaired, maintained and cleaned.

The importance of cleanliness is obvious in the city, but it is likewise important on country roads, from other than reasons of sanitation and appearance. A clean surface, being non-slippery, promotes safety. Recent experiments have shown that irregularities of surface due to unevenness and foreign material dropped by passing vehicles, or even accumulated refuse, induce, by increased impact, excessive strains in both the surface and pavement structure. A pavement properly maintained and cleaned, apart from increasing its life, safety, comfort and agreeableness to the user, can carry at least twice the load that a neglected surface can.

A pavement should have as low a crown or cross slope as conditions will permit, in order to encourage full use of the surface width. At intersections the crown should be carried through without inconvenience to the vehicle traffic on the more important street.

The character of the pavement surface should be varied to suit special conditions. In front of schools, libraries and hospitals a quiet surface is appreciated. On grades a surface that will give good traction, and possibly good foothold, is needed. At turns where proper superelevation cannot be secured it is often advisable to use a gritty surface and keep it clean. In other words, on any improvement the character of the surface, like the depth and strength of the pavement structure, must be adapted to the locality and to the requirements of the users.

Large radius corners should be used, as they promote safety, reduce congestion, reduce curb breakage and add to the comfort of the user. All abrupt changes in grade should be connected by vertical curves. All horizontal curves should be of large radius on through streets and properly eased at the tangents. Proper lighting, tree planting and street and route markers, add to safety, appearance and comfort.

Smooth Surfaced Pavements

Pavements that have a smooth surface or can be easily maintained and cleaned may be arranged in the following order:

Sheet asphalt on concrete base; asphaltic concrete on concrete base; brick with asphalt filler and concrete base; concrete with asphalt filled joints and cracks; creosoted

wood blocks as usually laid; sandstone blocks with grout filler; granite block with bit. mastic filler; brick or granite with grout filler; brick or granite with tar filler; asphalt macadam; water-bound macadam; and clay-gravel surface.

The foundation structure should be designed to fit the traffic and character of the subgrade. Its function is to support the surface. The surface should be designed to fit the needs of the location and the users. And these needs are, may it be repeated, comfort, safety and appearance.

The foregoing paper by Mr. Fixmer was presented at the annual meeting of the Illinois Society of Engineers.

EFFECT OF CAR TRACKS UPON TRAFFIC CAPACITY OF ROADWAYS

By Geo. W. Tillson, Consulting Engineer, 313 S. Catherine Ave., La Grange, Ill.

There is probably no one thing that is the source of so much trouble and annoyance to the official in charge of the maintenance of street pavements or road surfaces as the existence of street car tracks in these surfaces. This is mainly true because he has no direct control over the repairs required to keep the tracks in good condition. As a general rule the street car companies must keep in good repair the tracks and pavement between them as well as for a short distance outside. It is generally provided also that, if the corporation does not do this, it may be done by the municipal authorities. But the procedure is such, and so much red tape is involved in carrying out the legal requirements, so that the cost of repairs may be collected from the company, that the provision is seldom resorted to and it is generally considered better policy to try and have the necessary work done by the corporation itself.

Car Tracks in Street Often Necessary

While as has been said the existence of car tracks in streets and roads is annoying, the public authorities accept the fact that they are necessary. Transportation is a very important factor in any community, be it large or small, whether a city or a state, and it does not seem proper that existing routes of travel should not be made use of wherever possible. It may be said of course that street car lines especially if suburban should secure their own rights of way. This may be true, as an abstract proposition. But it should be remembered that this involves a considerable increase in capital cost and to such an extent reduces the dividend to be paid from a certain fixed fare. This is exceedingly important at the present time when so many street car companies both urban and interurban are finding it impossible to meet their financial requirements with their franchise rates of fare.

The acceptance of this fact, however, does not mean that tracks are to be laid at any place or in any way as the company sees fit without regard to the public rights or needs; far from it, but quite the reverse indeed.

A discussion of the subject of this paper must necessarily be academic to a great extent; but it is hoped that the presentation of one or two concrete cases will be sufficient to illustrate the general idea.

Principal Items to Consider

The principal items to be considered in this connection are: the location of the tracks, their detailed construction, their degree of perfect maintenance, the character and amount of traffic on the tracks, and the character and amount of traffic on the street or road. The question of location is perhaps the one to be most considered as upon the location depends the importance of the other items. Its discussion too involves the problem of what is the best location for car tracks when they must be laid within the lines of streets or roads. The common practice with streets is to place them in the center, thus giving an opportunity for streams of traffic to move in either direction entirely independent of each other. With this arrangement it can easily be seen that the width between the cars and the curb will have much to do with the effect on traffic. In the Borough of Brooklyn, New York City, many street with roadways only 34 ft. wide have two lines of car tracks and some with a width of only 30 ft. In such cases the obstruction to traffic must be very great as the distance from track to curb is only 9½ and 7½ ft. respectively and even these distances are reduced by the overhang of the car itself. It is on streets like these that the items of construction, maintenance, amounts of traffic, etc., are particularly important.

The writer has always felt that a car track should be so constructed in a pavement that vehicular traffic could pass over it diagonally, squarely or in any direction without any real inconvenience, and that it should be so maintained that it would always meet this requirement. The heavy truck traffic that is so constantly increasing emphasizes this idea. With the present standard rails and latest construction there is no difficulty in meeting what is desired. Practically all electric roads in streets or highways are operated by overhead trolleys but in the Borough of Manhattan, New York City, where the underground trolley is used, it is necessary to have a slot half way between the rails of each track. This is also true of cable roads. Such construction makes is very difficult properly to maintain or lay the pavement. The space between the slot and rail is so narrow and so shallow over the conduit that carries the power that ordinary pavement methods are not successful. With the same amount of care in construction and maintenance such tracks are more of an obstruction to traffic than those used with the overhead trolleys. The writer once saw both in Brussels and also in Vienna an underground trolley system where the slot was built in connection with one of the rails leaving the entire space between the rails unbroken. This seemed much better work from a pavement standpoint but the engineer in charge of the railways of Vienna said it was not good for operation. Why, this was not explained but it was thought that possibly it would not permit so good an electrical connection with the car.

Some Specific Examples

The Board of Estimate of the City of New York has made a rule that a double track road shall not be laid in a street with a roadway of less than 40 ft. In Philadelphia where the streets are narrow generally but one track is laid in a roadway, the cars necessarily having different routes to and from the center of the city.

In some cases where tracks are laid in the center an area is curbed especially for the tracks, vehicular crossings taking place only at cross streets or other especially provided places. This is true in a few other cities, but almost generally so in New Orleans. Here the streets as a rule are wide, allowing plenty of room for this method

as well as for the general traffic of the city. In such cases, of course, traffic is not impeded at all except as to general crossing from one side of the street to the other.

Rochester, New York, has one or two streets where the tracks are located just inside the curb line. On one of the streets leading out of Paris the writer once saw a similar location. In Rochester the instance noted was on a distinctly residential street but in France it was in a small retail section.

With such a location the general street traffic would not be effected but it has always seemed to the writer that it must be very inconvenient to the people along the line, especially if it was on a business street. Here, however, again comes in the question of how much traffic the car line carries and how often the cars run.

Perhaps the best example of obstruction to traffic by car tracks of which the writer has any cognizance is in the Borough of Manhattan, New York City. Central Park West is that portion of Eighth Avenue lying directly west of Central Park. This Avenue south of 58th street is 100 ft. wide with a 60 ft. roadway with car tracks in the center. Central Park West is also 100 ft. wide but the roadway is only 48 ft. wide and the tracks are laid on the easterly side, the nearest rail being 3 ft. from the curb, leaving a free roadway of 29.9 ft. not taking into account the overhang of the car.

A New York Street

Central Park West is built up on the west side with business houses on its southern end and the remainder with large apartment houses. The cross streets too are well built up so that the local traffic is heavy. Previous to the introduction of the automobile the obstruction to travel was not so great. But it can easily be seen that with it being necessary for all pedestrians to cross two lines of vehicular traffic in order to take or leave a car a great deal of trouble must occur. So many accidents occurred that in 1913, the Board of Estimate and Apportionment passed a resolution directing the Railway Company to relocate the easterly track at its own expense with the intention of widening the roadway after this was done. It seems, however, that the tracks were located in their present position in 1897 at the request of the Park Commissioner of the City and the Corporation Counsel advised that a court seeking to do equity might well deny the application to compel the Company to again relocate its tracks entirely at its own expense. The estimated cost of the work was $352,000. Many communications passed between the City and the Railway Company in regard to the matter but no physical work was ever done and the tracks and roadway still remain as herein described. The police reports show that on this street 286 accidents occurred during the years 1910 to 1913 inclusive. In addition to the accidents to persons the Police records show that in 1913 there were 36 collisions between vehicles and 8 collisions between vehicles and surface cars. It is also stated that probably only the most serious vehicle collisions are included in the police records. No doubt the number of accidents have increased in subsequent years. In any event, recently Central Park West has been made a one way street so as reduce the number of accidents to a minimum. In order to understand just what this means it must be remembered that Central Park extends in width from 5th avenue to 8th avenue, a distance of half of a mile, and that by making Central Park West a street for south bound traffic only this distance is increased by one long block so that all north bound traffic is cut off between 5th and Columbus (old 9th) avenues. This of course increases the congestion on all north and south avenues. North bound automobile pleasure traffic, although permitted to go through Central Park, has but two outlets to the west so that if not through traffic it must be seriously inconvenienced.

Other New York Streets

Compare for a moment the situation on Fifth avenue south of 59th street. This street is also 100 ft. wide and prior to 1908 had a roadway of 40 ft. with sidewalk spaces 30 ft. wide, but areas and stoops were allowed to encroach 15 ft. so that the free width of the street was only 70 ft. The Board of Estimate and Apportionment by resolution widened the roadway by setting the curb back 7½ ft. on each side and ordered the encroachments back to within 2½ ft. from the property line, thus giving a roadway 55 ft. in width with sidewalks 20 ft. wide free from obstruction. The old roadway permitted four lines of traffic while the additional 15 ft. in width furnished space for two more and even this is insufficient for the traffic requirements.

The large cars of the Brooklyn Rapid Transit Company, when passing occupy practically 19 ft. of space, 18.6 ft. to be exact. Supposing a double track line were laid in the center of 5th avenue, with the traffic it would certainly have when two cars met there would be left on each side a distance of 18 ft. only sufficient for two lines of travel, in other words, nearly all of the benefits of the widening would be lost.

Prospect Park, Brooklyn, has five sides and on all of the adjacent streets there are street car tracks. With one exception the location is similar to that on Central Park West. But on only one street, Prospect Park West, has it been necessary to establish a one way traffic. This is because both the local street car, passenger, as well as vehicular traffic is light. During the summer a large part of passengers carried by the car lines have the park itself as an objective and they of course are benefitted by having the tracks adjacent to the curb. The situation as a whole, however, well illustrates the bearing of both kinds of traffic upon the subject under consideration.

In another, but perhaps indirect, way can be shown somewhat how traffic is diverted on street car streets, and that is by its effect upon the pavements.

In the Borough of Brooklyn careful records have been kept of the cost of repairs to all pavements for more than 15 years, by individual streets.

The cost of repairs to asphalt pavements on streets without car tracks for the years 1914 to 1918 inclusive has averaged 2 cts. per sq. yd. and for streets with car tracks the cost has been 3.4 cts. While these figures prove nothing directly they are at least indicative as they give results upon 31,645,000 and 3,884,000 sq. yds. of pavement on streets without and with car tracks, respectively.

Tracks on Country Roads

The problem of track location on roads is somewhat different from that on streets as the local conditions are so different. Then, too, a country road, even if paved, seldom has its pavement of greater width than will accommodate expected vehicular traffic so that any interfer-

ence with existing pavement will be serious. Fortunately, however, there are generally no very serious objections to a side location, the tracks being sufficiently far apart to provide for ample width of the pavement between them. The new National Highway bill proposes, where feasible, a 66 ft. width of right of way and a pavement width of not less than 20 ft. This would give ample room for car tracks on both sides of the pavement. Whenever a wider roadway is required or any special local conditions arise each case must be considered on its individual merits.

If the tracks are located in the pavement whether in a city street or country road the shape of rail and method of construction become very important. As has been previously stated the mere existence of tracks in a pavement should not interfere with traffic. As a matter of fact they do. The writer some 25 years ago saw a track on 14th street, Borough of Manhattan, laid with two center bearing rails instead of one laid on longitudinal wooden stringers, the rails and tracks being so near and of such construction that traffic in the center of the street was almost entirely cut off. Fortunately such conditions do not now exist anywhere, but they illustrate the importance of the principle.

Type of Rail

No doubt the well known T-rail of the steam roads is the most economical type of rail for traffic. It does not, however, permit a smooth junction between the pavement and the rail either between the tracks or outside. This type of rail also is liable to cause ruts alongside the rail if the tracks are much used by vehicles. With the present grooved rail in use in most cities with a practically square edge on the outside and the flat lip on the inside, it is perfectly practicable to construct a track that *per se* will not interfere with traffic, especially if a 60 ft. rail be used. Specially burned brick or specially cut stone blocks are sometimes used in connection with the T-rail, the groove being really cut out of the blocks. This method often produces good results. On a country road where the tracks are laid outside of the pavement the T-rail can of course be used to advantage.

But whatever the style of construction it should be designed with the idea of keeping both the track and pavement in good condition. Unfortunately the track area of pavements in American city streets are not generally in good condition. Much improvement however, has taken place during the last 20 years and most street railroad companies realize that it is good policy to keep their plant well maintained. Again, unfortunately, soon after this realization the world war came on bringing with it financial changes to all but which seemed to injure street car companies more than almost any other corporations, bound as the most of them are by franchise obligations as to permissible fares with costs of labor and materials mounting up with aeroplane-like rapidity.

Conclusion

If, then, car tracks are to exist in paved streets or roadways they should be so constructed as to present as little interference as possible with the pavement.

Perhaps the most important item in construction is the type of rail to be used and this has previously been discussed.

The road bed and foundation too must be specially prepared. The rail must not give appreciably under car traffic as it is almost impossible to maintain any pavement against a rail that moves vertically under the passage of cars.

The joints, too, are a prolific source of trouble. Many times a hole in a pavement along the track has its origin at a defective joint. The use in the last few years of a 60 ft. rail has helped this situation very much. Admitting the force of the arguments used herein, it follows that street car tracks do obstruct traffic very materially when in use in streets or roadways.

It also follows that the extent of this obstruction depends upon the amount of existing traffic and location of tracks, being greatest where both tracks and roadway are used to their utmost capacity and the tracks laid in the pavement, and almost nil where traffic is light and the tracks located outside of the pavement proper. Probably no better illustration of the relative traffic capacity of street car and non-street car streets can be given than existing conditions on Jackson Boulevard and either Adams or Madison streets in the loop district of Chicago in the rush hours.

In designing a street or road where provision must be made for street car lines, a study must be made of both street car and vehicular traffic, present and prospective, so that the relative importance of each may be determined. As a general proposition the center of a paved street will be the correct location, but often special conditions may make a different one desirable. In the same way it might be said that on a country road the side location would be most logical, changing somewhat, possibly, when passing through small towns or villages.

Wherever the location the type of construction should be good, variations being permitted according to exact location and character and amount of traffic.

As careful provision should be made for the maintenance of the tracks and pavement to be kept in repair by the street car company, if any, as for the roadway pavement itself. The writer knows that this is often difficult but thinks that unless the Company is operating under a franchise giving it special privileges, good results can be obtained by some arrangement. If a new franchise is to be issued, the car company might be obligated to pay a specified amount with the understanding that the Highway authorities would keep the pavement in repair. The maintenance of the tracks and road bed must be left to the operating company.

The writer feels, therefore, that if these precautions are taken that while some traffic obstruction must, exist, it will in this way be reduced to a minimum and the general traveling public benefited as much as possible.

The foregoing paper by Mr. Tillson was presented before the 1920 annual convention of the National Highway Traffic Association.

SEWAGE DISPOSAL IN SMALL CITIES AND TOWNS

Written for Non-Technical City Officials

By Milton F. Stein, Civil Engineer, Chicago, Ill.

The necessity for sewage disposal works is more generally and more urgently felt in the smaller towns

at present than in the past. In some cases this is due to growth in population or more complete sewering, which has rendered former disposal works inadequate, or may have so increased the quantity of sewage as to cause nuisance and protest from dwellers along the watercourse into which it is discharged. Then again, an increasing number of small towns and villages are installing public water supplies, after which sewers follow as a matter of course, and the question of sewage disposal arises quite naturally or is forced upon the attention of these prospering and progressive municipalities by the proper state health authorities. To these reasons may be added the increasing appreciation of the importance of sanitation; and the continued improvement in practical sanitary methods, which has raised sewage disposal projects from the status of rather dubious experiments to that of matter-of-fact accomplishments. It, therefore, follows that many of the smaller towns are being confronted with the problem of building new disposal plants, or remodeling old one, which may be obsolete, inoperative through neglect, or outgrown.

The problems of sewage disposal for small towns are peculiar, and often differ considerably from those of the larger cities, if for no other reason, because the latter are usually located near some stream or watercourse of considerable size, whereas the location of the former is often dictated by some primary cause, such as the junction of two railroads, which may leave them high and dry insofar as a stream suitable for sewage purposes is concerned.

Mental Attitude Toward Sewage Disposal

The sanitary engineer cannot but be impressed with the popular mental attitude toward sewage disposal, as reflected in many instances by the municipal officials with whom he comes into contact. It is most important that this be corrected if necessary, as upon the proper point of view on the part of the municipal officials depends very largely the success or failure of any sewage disposal project. In the past there has been the very general thought, which still persists to some extent, that the average citizen's responsibility for the disposal of sewage ended with the connection of his house drains into the street sewer. If an officious state health board insisted on disposal works, these were built as cheaply as possible, and as remotely from human habitation, often adjacent to the municipal garbage dump and rubbish pile, and if not completely forgotten forthwith, were subject only to very occasional visits by some minor employe. This attitude has happily changed for the better to a large extent, but is still occasionally met with, and its results are, of course, existent in the form of disposal plants, which because of poor design and construction, and subsequent neglect, are useless, or worse.

It may seem rather impertinent, but it should nevertheless prove beneficial, briefly to outline the more basic principles of which the average municipal officials' mental attitude toward sewage disposal should be compounded.

There must be appreciation of the fact that the sewage from his town may constitute a nuisance to other communities, ranging from a mere affront to esthetic susceptibilities to an actual health menace. No town has the right to inflict such conditions on its neighbors, and in this matter faces a duty that it should not try to evade, as to do so would be detrimental not only to the general health but to common progress and betterment.

There must be reliance and confidence in the ability of the state health authorities to decide upon the existence of such a nuisance and upon its degree of seriousness, and a willingness to carry out their recommendations in a whole-hearted manner.

It must be realized that the art of sewage disposal is on a scientific basis. Many past failures have resulted from use of rule-of-thumb methods. The processes and reactions involved should be carefully studied for each specific case, and a special plan of procedure, based upon a thorough investigation and analysis of conditions, should be decided upon.

There must exist the resolution conscientiously to carry out the accepted plan in all respects, especially as regards the construction work, as any skimping may seriously affect subsequent operating conditions and even the durability and ultimate life of the disposal plant.

Cognizance must be taken of the fact that no sewage disposal plant will operate and maintain itself, and therefore any project must include the provision of an annual sum for operation and upkeep, the amount of which should be based on the opinion of someone versed in such matters, perferably by the engineer who has been entrusted with carrying out the project.

Making the Most of Old Plants

The writer is of the opinion that there are a considerable number of disposal plants which, though not up-to-date, are mainly inoperative through neglect, and with proper attention can do useful work for a number of years, or until they can be supplanted by modern plants. In many cases the first requirement is a thorough cleaning and overhauling, with minor repairs, and the washing and perhaps partial replacement of filtering materials. Where the plant has been outgrown, provisions can be made for treating sewage up to its capacity and by-passing the remainder. Certainly it is better, as a temporary expedient, to treat a considerable portion of the sewage, rather than to pass the whole of it through the plant in such a manner as to afford no treatment at all, as is usually the case in these obsolete and neglected plants. The important point, after overhauling is to give proper and intelligent care to the operation, which has often been more at fault than the obsolescence and inadequacy of the plant.

Selecting Type of Sewage Disposal Plants

Those contemplating new disposal plants, or extended remodeling of existing ones, are very likely to be confused by the newer developments in sewage treatment, which have been very widely discussed in the technical press of recent years. The last decade has seen the Imhoff tank supercede the septic tank, and the trickling filter has been in general use but little longer. Two more recent developments have been the activated sludge process and the fine-meshed mechanical screen.

Some credence has been given to the opinion that fine-meshed screens could compete on an equal footing with sedimentation tanks of the Imhoff type, whereas, their fields of usefulness are quite distinct and only overlap to a small extent. Where a relatively small amount of sewage is discharged into a large body of water, it is necessary to remove only coarse suspended matter in many cases, as dilution is sufficient to take care of the sewage without nuisance. The removal of coarse suspended and floating matter under such conditions is generally best accomplished by means of fine screens. Where it is desirable to remove a considerable proportion of the suspended matter, settling tanks are necessary. There is necessarily a region where conditions overlap, and where both screens and tanks may be considered with propriety.

There has been some complaint against the Imhoff tank recently, because of odors and foaming in certain instances. Undoubtedly under very abnormal conditions such trouble will occasionally occur. One possible source, which has not received the attention which it should, lies in the design. This is usually based upon a per capita basis—so many units of sludge capacity, settling capacity, etc., per person. On such a basis the propery balancing of the biological activities in the tank is likely to be lost sight of. Probably a more thorough study of each design from the dynamic point of view would be beneficial.

The activated sludge process offers a substitute for the Imhoff tank—trickling filter plant in the complete treatment of sewage. It is more compact and probably produces an effluent of greater purity. Up to the present only experimental plants have been in operation, if we include in that category two or three plants treating the whole sewage of small cities. The difficulties in this process are those of operating under the limitations of practical conditions as against experimental, and the disposal of the voluminous quantity of sludge formed.

As regards the choice of a system of sewage disposal for the town or small city, Pope's rule may well apply:

> "Be not the first by whom the new is tried,
> Nor yet the last to lay the old aside."*

As has been said before, every case requires special consideration, but to give the reader somewhat of an idea as to what plants would be suitable under various conditions, we may generalize as follows:

Where the sewage is discharged into rivers of great volume and rapid current, or into the open sea at isolated points, fine meshed mechanical screens may properly be used.

Where the sewage is received by rivers with a large minimum discharge, not grossly polluted, Imhoff tanks usually suffice.

Where the sewage is of large relative volume compared to the dry weather flow of the water course, in general whenever a town of several thousand inhabitants discharges its sewage into a creek or small river, complete treatment, consisting of coarse screens, grit chambers, Imhoff tanks, trickling filters and perhaps even secondary sedimentation basins, is usually necessary.

*Essay on Criticism, Alexander Pope, 1711.

Measures Preliminary to Construction Important

Of the measures preliminary to a sewage disposal project, the scope of this article prohibiting any discussion of the legislative and financial steps involved, we must limit ourselves to those having direct bearing on the design and construction work.

Most important is the obtaining of a record of sewage flow, and the variations therein, hourly, daily and seasonal. Even if no improvements are contemplated, every town and city should keep an accurate record of its sewage flow, based on daily or hourly measurements. Such data has many important and interesting applications. It furnishes the most reliable information as to the capacity of sewage disposal works required. It is very useful in connection with sewer design. The writer has found that taken in connection with the chemical analyses of the sewage, embracing those determinations which indicate the nitrogen present, it forms a basis for estimating the population of a town and its increase which can only be surpassed by a very carefully taken census. This may seem surprising, except to those who are familiar, through detailed study, with what is popularly called the "law of averages" or more correctly the "theory of probabilities," and therefore are aware that many very complex natural phenomena if due to a large number of causative factors, fall under the leveling influence of this interesting general law. It is usually possible to build a wier near the sewer outfall, and an automatic recorder, with clock driven chart, can be bought at a reasonable price. At least a year's record should be obtained if possible.

Chemical analyses are only second in importance to flow measurements. They can be obtained in much less time, a month being usually sufficient. The writer is aware that he is diverging somewhat from common practice in emphasizing flow records and analytical data, instead of basing the design upon population records, but a sewage disposal works is like a manufacturing plant in that it is required to assimilate a certain amount of raw material daily, and the above measurements are the only ones from which this amount can be accurately computed.

Other preliminary data is that usually covered in the engineer's report and need not be discussed here.

Generally elaborate experimental tests are not called for, but if the above analytical data shows the sewage to be peculiar, for example, due to the presence of large quantities of industrial wastes, then experimental treatment is often justified, and may save money in the end.

Description of a Typical Plant

Very naturally, many municipal officials have but meager knowledge of the details of a sewage disposal plant and of the processes of purification, since their interest in the subject of sewage treatment was only aroused upon assuming office, by the special problems which they found confronting them. It is quite labori-

ous for them to acquire the desired information by a study of the various treatises on the subject or by a search of the technical periodicals. It may not be out of place, therefore, to conclude by very briefly describing a typical plant of the Imhoff-trickling filter type, which, as has been mentioned before, best meets the requirements for complete treatment of the sewage in small and medium-sized towns, and by omitting the filters, leaves the partial treatment plant such as suffices when the effluent is discharged into a fairly large river.

A general view of such a plant is shown in Fig. 1. The sewage, entering from the left side of the illustration, first passes through a screen of iron bars, which holds back large floating matter, such as sticks of wood, large leaves, rags, etc., that might clog the pumps or otherwise interfere with the operation of the plant. The screenings are raked off by hand, and either buried or incinerated. Then the sewage flows through two long, narrow grit chambers, arranged in parallel, wherein the sand and grit settle out. These chambers require occasional shoveling out, for which purpose they are first drained. The grit is inoffensive and may be used for filling around the plant.

The picture shows a pumping station, for elevating the sewage from the grit chambers to the Imhoff tanks, In many cases, where sufficient fall is available, this is not needed. However, some sort of structure to serve as a tool house and office is very desirable in all cases.

The purpose of the Imhoff tanks is to clarify the sewage by removing the settleable solids. They are settling tanks, but peculiar in containing two stories. A typical section is shown in Fig. 2. The sewage flows slowly longitudinally through the upper portion of the tank, allowing the suspended matter to precipitate to the inclined false bottom, down which it slides. At the lowest point is a longitudinal slot which permits the precipitated solids to pass through, but is so constructed as to prevent the gas formed by decomposition in the lower compartment from rising upward through it and interfering with the process of sedimentation. In the lower compartment the precipated solid matter accumulates and is digested by bacterial action. In the absence of light and oxygen and in the presence

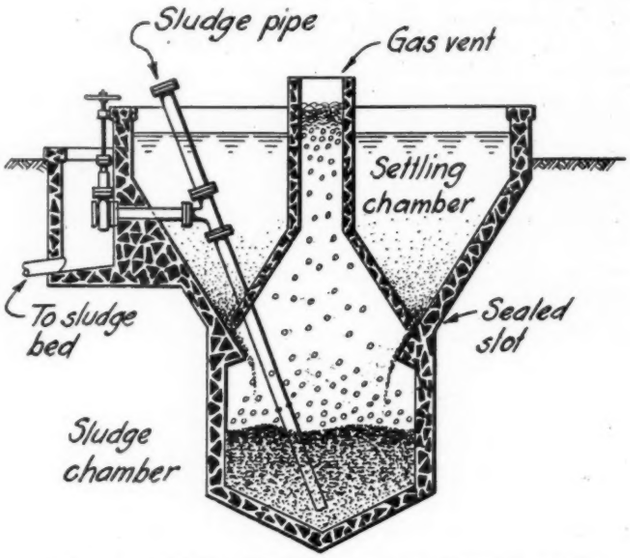


FIG. 2. CROSS SECTION OF AN IMHOFF TANK SHOWING THE PRINCIPAL CONSTRUCTION FEATURES AND MODE OF OPERATION.

of large quantities of organic matter, certain types of bacteria multiply greatly in this lower chamber, and these break up the organic solid matter present into simpler forms, partly gaseous, which escape through the central gas vents, and partly solid which remain. During the summer months this accumulated solid matter is drawn off at intervals through the sludge pipes and allowed to flow over the sludge beds, two of which are shown in the foreground of Fig. 1. Here it is dried by the sun, leaving a porous, grey, spadeable residue, very like rich black soil, and suitable for the same purposes.

The clarified sewage flows from the Imhoff tanks to two dosing tanks, which are equipped with automatic

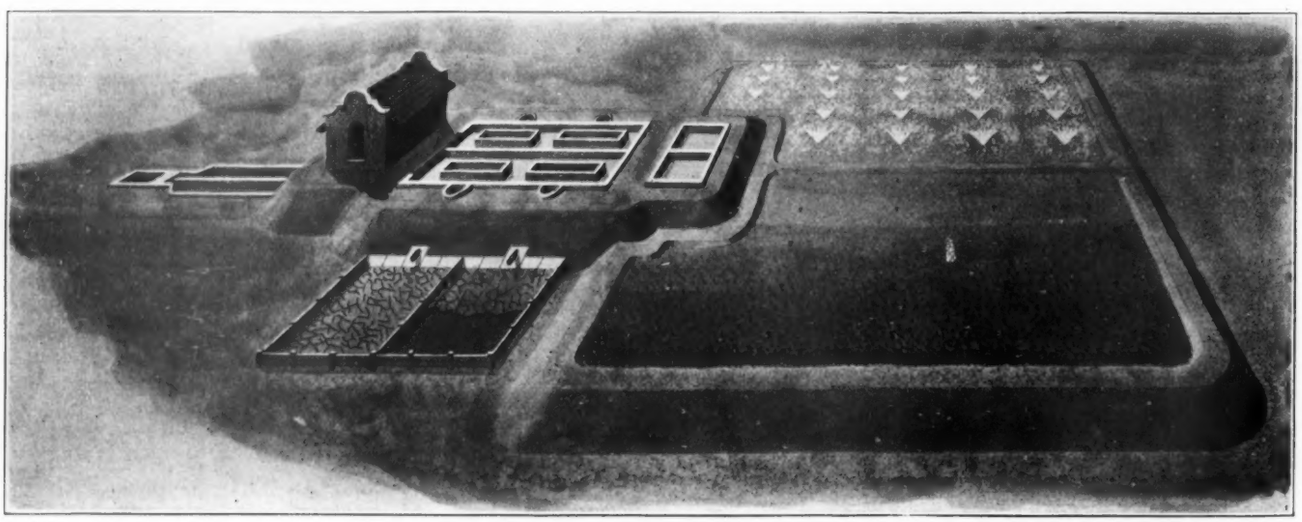


FIG. 1—GENERAL VIEW OF A TYPICAL SEWAGE DISPOSAL WORKS SHOWING, FROM LEFT TO RIGHT, BAR SCREEN, GRIT CHAMBERS, PUMPING STATION, IMHOFF TANKS, DOSING TANKS AND TRICKLING FILTERS, WITH TWO SLUDGE BEDS IN FOREGROUND.

syphons, whose purpose is to discharge it intermittently and alternately into the pipe system which distributes it over the trickling filters. The distribution is effected through regularly spaced nozzles, which spray the sewage uniformly over the whole surface of the filters. Fig. 3 shows a section of the filters. The filtering material, approximately 6 ft. thick, is coarse crushed stone or slag. The sewage trickles slowly down through this. Bacterial action plays an important role here also, but oxidizing bacteria prevail. The

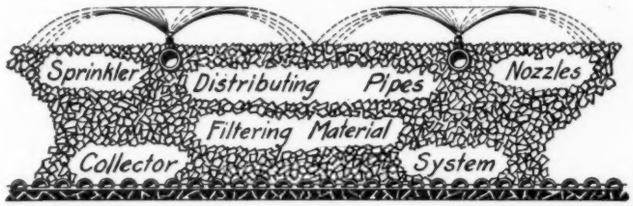


FIG. 3. SECTION THROUGH A TRICKLING FILTER SHOWING DISTRIBUTION OF SEWAGE THROUGH SPRAYING NOZZLES, THE FILTER BED AND UNDERDRAIN SYSTEM.

process involves, first the removing of fine colloidal matter from the sewage, and then the oxidation of this and part of the dissolved putrescible matter into a stable condition. The filters are underlain with a collector system and drains, which discharge the now purified sewage into the stream or river. This effluent is fairly clear and non-putrescible.

At times trickling filters will unload or discharge the accumulated solid matter with the effluent through the drains. Where it is not permissible to have this enter the stream, secondary settling tanks must be installed after the filters, where this may settle out. It is a humus-like material, somewhat like the Imhoff sludge, only much more watery.

Where the effluent enters a river the water from which may be used for drinking purposes further down, it should be disinfected, which may be done by the use of either hypochlorite of lime in solution or by the application of chlorine gas.

IMPACT TESTS ON ROADS

By C. C. Wiley, Assistant Professor of Highway Engineering, University of Illinois, Urbana, Ill.

There is probably no detail of pavement design receiving anything like the attention at the present moment that is being given to the determination of the thickness and make up of the slab. This is as it should be, for with the estimates placing the funds available for road work in 1920 at better than $600,000,000 and with enough city pavement work in sight to push the grand total beyond the billion mark, and with the prospect that the figures will grow in the future it is absolutely imperative that we build with the greatest wisdom and true economy. By building too lightly we can waste enormous sums in maintenance and reconstruction and by building too heavily we can work another great waste in time, labor, materials and equipment at a time when they can ill be spared. And since the cost of right of way, grading, etc. is nearly independent of the pavement detail it is evident that aside from the width of the slab it is the thickness that controls the expense. It is therefore only just that this question should be receiving unusual attention.

Must Design Roads to Carry Trucks

A scant fifteen years ago we faced a great change in road design in changing from the accepted types for horse drawn traffic to those which would serve under the high speed motor vehicle. And here again when we have barely reached a solution of the problem we are confronted with a new and more difficult one for the budding automobile has blossomed into the motor truck and highway transport is an established fact. We therefore find ourselves now facing the unfortunate and dangerous condition of being compelled to expend great sums in construction while readjusting our designs to a new class of traffic which exerts a different destructive action on the roads than that with which we are familiar. We must therefore learn to design our pavements so that under given conditions of climate and soil we will know they are adequate for the loads just as we can design our bridges to be adequate under the same conditions.

How About Highway Bridge Design?

In the early days of bridge building "rules of thumb" served instead of design, but as loads increased these were not adequate. Study and test revealed methods of strict analysis and the adequate design of parts. But even then results were not wholly satisfactory and a little observation and study showed that a train although running on smooth steel rails set up impact stresses. Further investigations indicated the magnitude of these stresses and in all good designs they are allowed for. At the present time, however, the impact allowances on highway bridges are generally determined by the same rules as for railroad bridges, and the question might well be raised here as to whether our highway bridge designs may not need some revision in view of the results being obtained on the actual impact of moving loads on highways.

The Design is the Thing Nowadays

In the early days of road building "b' guess, b' gosh" served for design. In fact, roads were not designed, they were just built, and it is only recently that it is being realized that the designing engineer is fully the peer if not the superior of the construction engineer. But with light loads, slow speed, and low prices the lack of true design was not greatly felt. But with present speeds, loads, and prices, design becomes highly important and it will require only a short ride over a rough pavement experiencing the bumps and jolts, or standing on a hard road while a heavy truck goes by and noting the jar and vibration, to convince anyone that impact surely has some place in the proper design of the structure.

Millions for Construction, but Scarcely a Cent for Investigation

The idea of trying to determine the amount of impact is by no means new. It must have occurred to every road builder of an inquiring turn of mind, and I know for a positive fact that it has been given serious consideration for 15 years or more. But such work requires funds to carry it through, and it is a curious fact that even at the present time, with our enormous appropriations for road work, the amount available for fundamental investigations is discouragingly, in fact almost criminally, small.

Money is available for everything except the fundamental studies on which the safe, sane and economic expenditure of the balance depends. Consequently, practically nothing was done, although experiment stations and highway departments were ready, willing, and equipped to do the work for the bare cost of labor and materials—the brains in general being donated, for rarely if ever have the brains been commensurately rewarded. Finally, however, that small, but highly developed, organization which lies tucked away—in fact, almost buried—in the Department of Agriculture, the U. S. Bureau of Public Roads, fell heir to some funds and undertook the basic studies of the impact on roads.

Basic Studies of Impact on Roads

It is impossible in the brief time available to enter into a detailed study of the data so far obtained by the Bureau of Public Roads, and I shall therefore limit myself to sketching some of the more salient points of the investigation. For the data I quote I am indebted to the article in Public Roads, and other papers by Messrs. Goldbeck, Pauls and Smith, of the Bureau of Public Roads.

Effect of Static Loads

Obviously, the point of beginning of any studies into the stresses in pavements is the determination of the effect of static or quiescent loads. If we assume that a subgrade is incompressible, then the only result of a load is to put compression into the slab, but if the subgrade is compressible, or for any reason fails to support the slab, then internal bending stresses are set up whose magnitude are dependent on the amount of load, the thickness and character of the slab, and the conditions of support. For simple beams and slabs the solution is not difficult, but for the complex conditions affecting a pavement, recourse to tests to determine the factors was necessary. This the Bureau of Public Roads did. (See Public Roads, April, 1919.) Numerous measurements were made, but the most significant is that with a wheel load of 8,500 lbs. on an 8-in. concrete pavement, supported on a subgrade of wet clay of low-bearing capacity, the fiber stress in the concrete amounted to but 34 lbs. per sq. in., or about one-fifteenth of the ultimate strength of the concrete. This load is about equivalent to that of the rear wheel of a 5½-ton truck. If this is true, is it necessary to build a slab 8 ins. thick? If not, why do we do it? If it is, impact must be the answer, at least to a considerable extent, and we will see a little later that the discrepancy is not so large after all.

Two Specific Problems

Assuming that impact is an active factor in road design, the specific problems before the investigators are: (a) The amount of impact delivered to the road surface by different vehicles under different conditions, and (b) the effect of this impact on different types of road surfaces. These are the problems being worked on by the Bureau of Public Roads. The first has progressed some distance, while the second is not as far along.

Test Methods and Equipment

Naturally some difficulty was experienced in developing satisfactory methods and equipment, but as finally employed they are briefly as follows:

A concrete box or pit was built into the road. In this was placed a contrivance similar to a hydraulic jack, the plunger of which carried a plate to receive the truck wheel. Auxiliary parts enabled the front wheel to be carried over this plate and then cleared so that the impact from the heavier rear wheel would be secured. To measure the impact, cylinders of pure copper carefully machined to exact size, ½x½ in., specially heat-treated and calibrated by submitting a certain percentage to pressure in a standard testing machine, were used. One of these cylinders was placed under the plunger of the jack, the impact of the wheel received on the plunger, and then the deformation of the copper cylinder accurately measured. Knowing the static load to give various deformations, these measurements indicated the impact load in terms of the static load.

Various Methods Employed

Evidently there are a number of ways in which truck wheels can deliver impact to a road surface, and consequently several different methods were employed to approximate some of these conditions. For example, in some instances the wheels were permitted to drop abruptly onto the plunger plate, in others obstructions were placed on the plate and run into by the wheel, and in others wedge-shaped plates were used, the wheels either being permitted to run over the wedge or to jump onto them from a take-off, thus simulating the running through or dropping into a depression with sloping sides. All of these methods were of interest and at the same time pointed out under which conditions the maximum impact was to be expected, which of course is the condition for which the design must be made. Different sizes and makes of trucks were used. The data so far, however, applies only to solid rubber tires, but the work is being continued with pneumatic and special forms of tires and wheels.

Sprung and Unsprung Loads

Before going further it may be well here to call attention to a few points concerning trucks which are well to keep in mind in further discussion of the subject and in following up the further reports of these tests.

The frame, motor, body and load of the truck rests on springs supported on the axles and is here termed a "sprung" load. The weight of the axles themselves, lower parts of the springs, the wheels and part of the drive mechanism is carried directly to the road without the intervention of springs, and is termed the "unsprung" load. When unloaded a spring has a certain neutral shape. As more and more load is applied it is deformed, becoming stressed to the amount of the load and having a tendency to come back to neutral size by the amount of this force. If the support of the wheel is removed it drops by its own weight, plus this "kick" of the spring, the load following only as the tension of the spring is relaxed. If the fall is great enough before the wheel reaches a new support, the spring may reach its full neutral shape or even expand beyond it before again picking up the load. It is in fact this action which makes the spring effective. The inertia of the falling load coming onto the spring again will compress it farther than its normal amount for that load, and there follows a rebound—in fact, a series of them, with a harmonic period and a decreasing amplitude, depending on the dimensions and make-up of the spring, unless the wheel in the meantime strikes a new depression or obstruction.

Keeping these facts in mind, it will be seen that a wheel

dropping suddenly into a shallow depression will strike with the full effect of the unsprung weight, backed by all the kick of the spring, the inertia of the sprung weight carrying it along so as to contribute comparatively little to the impact. As the depression becomes deeper the effect of the kick becomes less and of the sprung load more, as it is following the wheel down and must be picked up and supported by the springs in a short period after the wheel strikes. At some depth the effect of the unsprung weight will be neutralized by the rebound of the spring, and the impact, of course, greatly modified. At greater depths the impact will be due only to the falling of the gross load, modified by the easing action of the spring on the sprung portion. The resultant rebound of the spring will cause a series of secondary impacts of decreasing amounts at points, depending on the period of the spring and the speed of the truck. So far as I can learn, only the initial impact has been studied, and the others are probably much less.

Some of the Test Results

Turning now briefly to some of the results of the tests we find the following of especial interest:

A series of tests was run, using a Class B 3—5-ton army truck. This truck had a gross load on one rear wheel of 7,750 lbs., of which 1,837 lbs. was unsprung. Incidentally, this was a high proportion of unsprung weight. In general, the impact increased somewhat with the speed and amount of fall. The impact due to striking an obstruction running over an incline or striking an incline after a jump was much smaller than for a direct, sudden drop, and showed a proportionately somewhat greater increase with speed. For a direct drop the maximum impact was secured with a fall of 3 ins. at a speed of 15 miles per hour. The impact load in this case amounted to 42,000 lbs., or 5.4 times the static load. Since the stress in an 8-in. concrete slab for this static load is about 30 lbs. per square inch, the effect of impact is to increase this stress to about 170 lbs. per square inch, or to about one-third the ultimate strength, which apparently is something nearer the designing ratios familiar to the structural engineer than the figures mentioned earlier. Owing to the spring action, the impacts for small drops were relatively high. This truck gave a value of 28,000 lbs., or 3.6 times the static load, for a drop of only ¼ in. at a 15-mile speed. As drops of this amount are by no means uncommon, as, for example, between adjoining slabs, car track rails, etc., it is evident that this is worthy of note in our design. And it serves to show also the importance of eliminating the small depression, which is perhaps worse proportionately than the big one. It is worthy of note, however, that the impact against an incline increases with the slope, as would be expected, and consequently depressions of easy slope are less important than those more abrupt.

Another series run with a 5½-ton truck having a gross wheel load of 8,060 lbs. and an unsprung load of 1,000 lbs. showed the same characteristics of the impact as the army truck, but the impact values were materially lower, explainable only by the lower unsprung weight of the 5½-ton truck.

A series with a 1½-ton truck having a wheel load of 3,475 lbs. and an unsprung weight of 1,065 lbs., showed also the same general characteristics of impact as the heavier trucks, but, of course, considerably less in magnitude.

Effect of Unsprung Load

As a whole, the tests demonstrate conclusively that heavy motor trucks do exert an impact pressure on the road which may run several times greater than the static loads. The maximum obtained with the equipment so far was for a 5-ton army truck as given above, amounting to 42,000 lbs., with a static load of only 7,750 lbs. There are other points, however, of equal interest and perhaps of as great significance. At a 15-mile speed and with a drop of 2 ins. this truck gave an impact of 34,500 lbs., while a standard 5½-ton truck with a wheel load 310 lbs. greater, but with an unsprung load 837 lbs. less, caused an impact of only 23,500 lbs. This is a very interesting item as concerning the effect of the relative amounts of sprung and unsprung loads. The 1½-ton truck, however, under the same conditions, although having a somewhat greater unsprung load than the 5½-ton, showed an impact of only 14,000 lbs., indicating that it is not the unsprung weight alone that affects the impact. And when it is recalled that it is the load carried which gives the compression to the spring, which, in turn, increases the impact of the unsprung portion, the reason why the lighter truck shows relatively lower impact is evident.

Effect of Speed on Impact

Another point of interest is in regard to the effect of speed on impact. Usually impact has been said to vary with the square of the speed, and while the data available is not sufficient to indicate the true relation, they do quite definitely indicate that the variation is something less than the second power.

Again, the tests show that the impact does not vary directly with the drop, but is modified by the ratio of sprung and unsprung loads, making it probable that trucks of different types and build may give entirely different impacts, although carrying the same gross load on the wheels.

The application of the results of these tests may lead to some decided changes in the design of road slabs, especially those of concrete or monolithic brick. The theory of static loads indicates that the strength of a beam varies with the square of the depth. This theory has been applied in comparing different slabs for strength. It is the one used by the writer in his slab tests, and is the one used by the Illinois Highway Department in making the so-called comparative designs of different pavements. On the other hand, the theory of impact indicates that the strength of a beam varies directly with the depth. Since the action of springs, tires, etc., probably modifies the impact, it would seem probable that the true relation for strength is some function of the thickness of the slab lying between the first and second power, and it is hoped that these tests will aid in solving this part of the problem also.

Effect of Impact on Different Types of Roads

The second part of the impact tests is to determine the effect of impact on different types of roads. For this purpose sample sections of many types have been built, half of them on a dry, well-drained subgrade and half on an artificially saturated subgrade. A special impact machine to imitate the action of the rear wheel of a 7½-ton truck having a gross load of 12,000 lbs., of which 3,000 lbs. is unsprung, will be used in testing these sections. As yet

no data are available, but it will be interesting to watch for these results, for possibly some of the most far-reaching modifications in the choice and design of our pavements may develop therefrom.

Along in the early nineties the concrete pavement and the grout filler for brick were introduced. Time has developed them, and now we stand committed to these "rigid" types. But only time and study and perhaps the results of these tests, indicating the effect of impact on the various types of roads and the abilities of these various types to absorb or resist the jar and vibration, will indicate whether the rigid types will in reality carry the modern truck or whether we must swing farther along the eternal cycle and evolve elastic or resilient types to take their places.

The foregoing paper by Professor Wiley was presented at the 1920 annual convention of the Illinois Engineering Society.

FEATURES OF HIGHWAY WORK IN MISSOURI

By Alexander W. Graham, State Highway Engineer, Jefferson City, Mo.

The end of 1919 found Missouri enjoying the greatest road building movement in her history. Counties and road districts had voted $18,112,000 in bonds for the construction of state roads in each county with state and federal aid. As a result of the bond activity, the State Highway Board had approved applications for 734.67 miles of hard surfaced road, which, when completed, will cost a total of $10,226,646.34. The Bureau of Public Roads having Mr. H. H. Lotter, a resident engineer located at the state capitol at Jefferson City, to pass upon Missouri projects these applications had been rushed to Washington and 49, with a total mileage of 459.29 miles, and a total estimated cost of construction of $5,948,910.83, had been approved.

New Missouri Road Law

Missouri, except in isolated districts, had been doing little but *talk* good roads before the beginning of 1919. The close of the war found the whole country in the mood to build roads, and develop the country's resources, and the last Legislature, by passing a new road law, gave Missouri an appropriate vehicle for a great road boom. The general approval and working success of the law has been gratifying to Governor Gardner, who has been constantly pleading for good roads since he was elected and generously helping forward the present movement.

The new law authorizes the building of not less than 50 miles of state road in each county, which shall connect with the state roads in adjoining counties. On this mileage each county receives $1,200 a mile free including the cost of survey. Half the cost of building a durable road above $1,200 a mile is borne by the state and federal government, and half by the county.

The law guarantees that each county shall receive not less than $60,000 in state and federal aid on 50 miles of state road, but if a county can not build a durable road that will take care of local traffic and preserve the original investment with $1,200 a mile, and the county refuses to finance the cost above $1,200, the State Highway Department is authorized to cut the mileage and build as many miles of durable road as possible with the $60,000.

This law gave a new impetus to durable road building in Missouri. There was started a movement in almost every county in the state to vote road bonds to build the mileage authorized in each county.

The new road law went into immediate effect when Governor Gardner signed it March 17. But in spite of the fact that it took some time to acquaint the counties with its true provisions, certain portions of the public press having put forth the impression that it was a mud road law, the amazing total of $18,112,000 had been voted by the end of 1919, and petitions were in circulation asking county courts to set elections for an additional total of over $15,000,000. A majority of these elections will be set for January, February and March.

Activities of Counties

Most of the counties that have not yet done so are striving to finance their two roads and build something more substantial than $1,200 a mile roads. There have been bond failures, but the road boosters in the unsuccessful counties keep on trying, a failure merely spurring them on to greater efforts. With the bonds already voted and the proposed issues in sight, the indications are that most of the counties will have their two state roads financed early in 1920.

Of the $18,112,000 in road bonds voted in Missouri only about $6,500,000 was voted during 1916, 1917 and 1918, but all of that issue was tied up in the courts and not a dollar of it became available for road building until the new law was enacted. After the law went into effect it became necessary for the State Highway Department to go to the counties and subdivisions and induce them to vote bonds to provide means for launching the road programme it authorized. Pettis County took the lead, voting $500,000 June 3, and since then there has been a wide spread movement in the state to provide funds to meet the requirements of the new law. And the splendid record of the Department to date has been made in the face of organized opposition in different sections of the state.

During 1917, 1918 and 1919 Missouri completed 480 miles of road with state, federal and county aid. Of this mileage 90.8 was of gravel, 25.6 of macadam, 7.9 of chats, 7.8 of bituminous macadam, 2 of asphaltic concrete, 2.7 of Warrenite, 6.5 of concrete and 336.7 of graded earth. The earth road was constructed prior to the passage of the new law. The total cost of this work, which includes bridges and culverts, was $1,106,600.

Many Contracts to be Let

Many contracts have been let and many more will be let shortly, the work to start this spring, for the construction of the projects approved under the new road law. Work is now under way on 97.25 miles of road and ready to begin on 21.72 miles more when the weather permits, distributed as follows: 7.65 miles of gravel and macadam in Callaway County; 13.5 miles of concrete in Jasper County; 3 miles of bituminous macadam in Boone County; 6.5 miles of chats in Vernon County; 26 miles of gravel in Cole County; 15.5 miles of concrete in Mississippi County; 27.5 miles of gravel in Scott County; 2.2 miles of asphaltic concrete in Buchanan County; 19 miles

Bad Roads Waste Money

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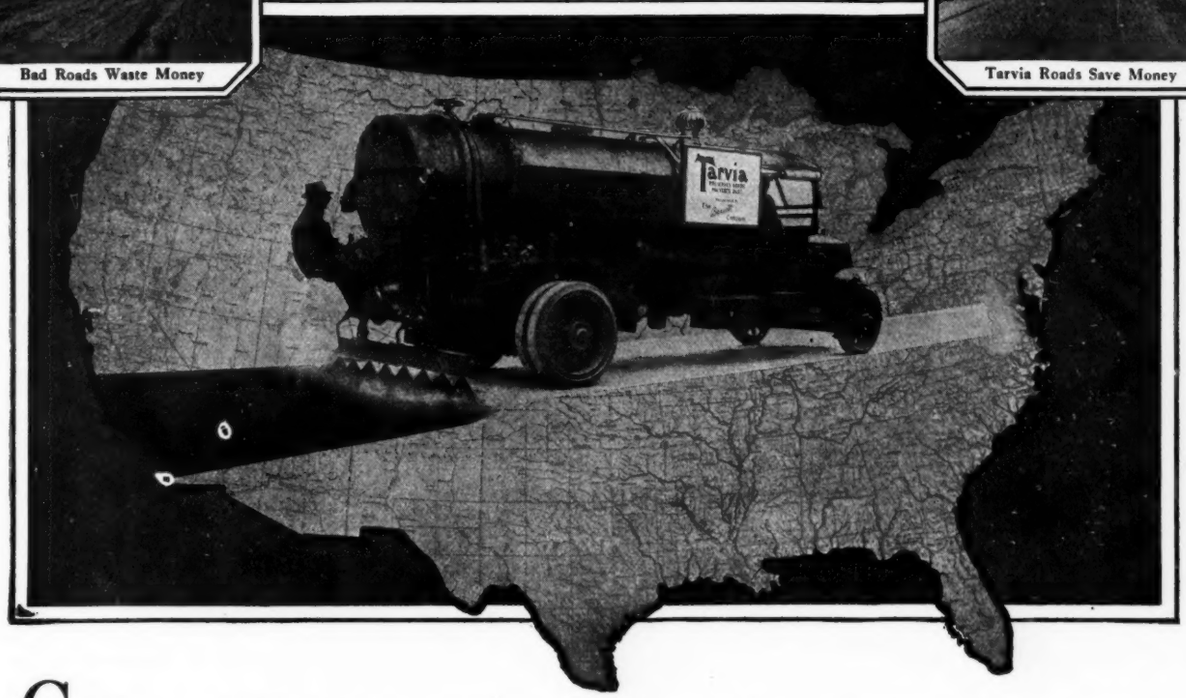

COME to think of it, is there anything so expensive to a community as *bad roads?*

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People tolerate bad roads year after year because they *think* good roads cost too much.

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2. Its initial cost—
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4. Durability—
5. Ease and rapidity of construction—
6. What "Barrett Service" can do for you.

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of concrete in New Madrid County; 5.3 miles of bituminous macadam in Pettis County; 13.07 miles of bituminous macadam in Clay County; 1.76 miles of brick in Randolph County and 1.6 miles of bituminous macadam in St. Charles County. The total estimated cost for the construction of this mileage is placed at $1,108,824.71.

More miles of state and federal aid roads would have been under construction during 1919 if contractors had bid more freely upon advertised projects. The new road law requires conpetitive bidding, and when no bids are received within the estimate, the State Highway Department is authorized to complete the project by private contract, force account or otherwise, provided it can be done within the estimate.

Failing to receive any bids, the Department was forced to enter into a contract with the State Prison Board for the building of 7.65 miles of gravel and macadam in Callaway County with convict labor, and the scarcity of contractors and the great number of projects to be let this year will force the Department to build other roads with convicts. About the only projects which atract road building contractors call for expensive concrete, brick and macadam roads. Counties preparing to build the less expensive rqads will be forced to organize local contracting concerns, and that is now being done in many counties, in order to build this year the many roads that have been approved.

The roads to be built in Missouri this year with state and federal aid will be almost entirely of a hard surfaced type. Of this mileage embraced in the applications that have been approved by the State Highway Board, contracts for the construction of which this year will be let shortly, 475.16 miles are to be of gravel to be constructed at a total estimated cost of $3,299,147.53; 100.95 miles of concrete at $3,461,452.01; 80.144 of bituminous macadam at $1,959,263.64; 8.241 miles of macadam at $62,043.41; 19 miles of water bound macadam at $170,869.88; 8 miles of asphalt at $142,053.45; 6.54 miles of Joplin chats at $41,514.00; 19.42 miles of brick at $847,338.63; 17.22 miles of graded earth at $242,973.00.

Road Surveys

The new road law authorized the designation of 6,000 miles of state road in Missouri and directed State Highway Engineer Graham without delay to survey and make plans of this mileage. It fixed the cost of the surveying and plans at not over $100 per mile on the average, the cost to be deducted from the $1,200 a mile which each county was to receive free on not less than 50 miles of state road.

The engineering department promptly placed six state surveying parties in the field, made contracts with private engineering firms and gave permission to counties desiring to do their own surveying for about 2250 miles of road. By Dec. 1, 1919, when freezing weather forced the suspension of work in the field, one-third of the 6,000 miles had been surveyed. Six hundred miles of this work had been done by the state parties. If the present rate of surveying can be continued all of the authorized mileage will be done by the end of 1920.

Surveys have been made in whole or in part in 86 counties. In the remaining 26 counties no start has been made, but work in them will begin as soon as the weather permits in the spring.

The surveying by the six survey parties has been done at an average cost of about $75.00 a mile, leaving $25.00 a mile for the completion of the plans. The balance of the surveying by the counties and contracts with private engineering concerns has been done at the price authorized by law and what the county agrees to pay in addition, and that includes the plans.

This year promises to surpass 1919, in road building as far as 1919 surpassed previous years. The State Highway Board, at its meeting Jan. 13, 1920, started the new year by breaking all previous records in approving applications for the construction of state highways with state and federal aid. Sixteen projects, calling for the construction of 157.61 miles of state road at a total estimated cost of $2,943,692.18, were approved. This brings the total mileage of state and federal roads approved to date up to 853.48 miles, which will cost a grand total when completed of $11,297,910.29.

There is nothing speculative in the $11,297,910.29 worth of road work that has been approved to date. It represents the real road building situation in Missouri, for the State Highway Board has not approved an application for state and federal aid until it positively knew that the county, subdivision or interested parties making the application had provided its part of the money to build the road.

CONSERVING POLES AND POSTS

Timber suitable for telegraph and telephone poles, fence posts, etc., is becoming scarce and expensive. It is estimated by the Forest Service that 60 years hence will witness the practical extinction of such material. At present about 4,000,000 poles are being erected annually. Records compiled by the Forest Service show that 95 percent of all poles are destroyed by decay, 4 percent by insects and the remaining 1 percent by mechanical abrasion.

Scientists who have been giving the subject attention advise, as a result of experiments conducted by them, that creosote treatment applied to the ends of the poles and posts imbedded in the ground will lengthen the life of the poles as per the following tabulation:

White cedar ..16 years (untreated) to 30 years (treated)
Cypress .....6 years (untreated) to 15 years (treated)
Chestnut ....12 years (untreated) to 16 years (treated)
Pine .....6½ years (untreated) to 20 years (treated)
Juniper .....8 years (untreated) to 18 years (treated)

There are three methods of treatment adaptable to the purpose: The open tank method, whereby only the butts of the poles are treated; the pressure process, used only on short poles, and the brush method, which may be applied in the field as the poles are being set. The employment of the open tank method calls for the application of the treatment before the poles are shipped on the job.

As creosote and the labor required to apply it are much cheaper than new timber, it is needless to say that railroad companies, telegraph and telephone companies, farmers and all others using large quantities of timber for poles and posts are giving this matter much serious consideration. Even yet, however, entirely too many posts are being set untreated and unprotected. This is a form of business extravagance that is unwarranted.

WATER WORKS SECTION

TWIN FALLS, IDAHO, WATER SUPPLY AND PURIFICATION PLANT

By Robert E. McDonnell, of Burns & McDonnell, Consulting Engineers, Interstate Bldg., Kansas City, Mo.

About ten years ago upon the site where Twin Falls, Idaho, now stands there was nothing more than a barren sage brush waste; therefore, water for irrigation and domestic needs has played an important part in the upbuilding of this modern city, which now has about 10,000 population.

Water Supply

In providing water for irrigating the farms, the city also is provided through the same canal water for its domestic needs and fire protection. The water supply is from the Snake river, taken from a canal which is located about 2½ miles south of Twin Falls. From this canal the water for municipal use flows through a 24-in. pipe line, passing through a Venturi meter and also through a float valve, which automatically regulates the elevation of the water in the receiving basins.

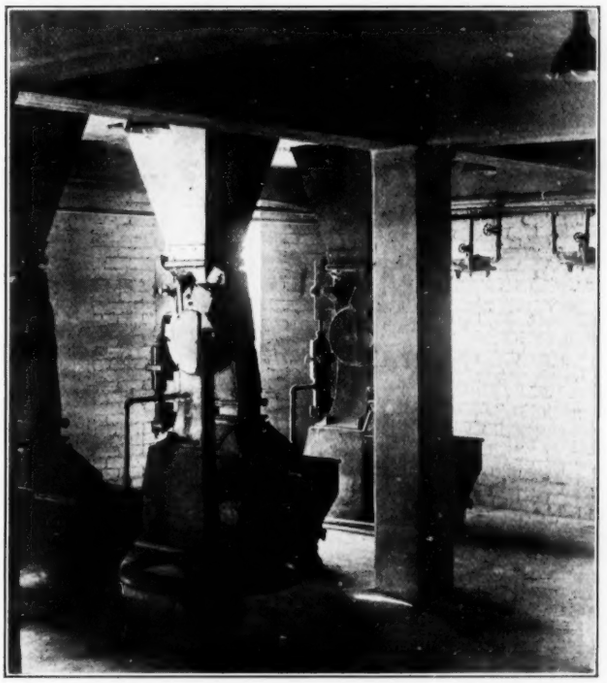
The water supply for Twin Falls, as in all other western cities, must be an adequate volume for garden irrigation, lawns, and an unusually large amount for domestic requirements because of the very dry summer seasons. This necessitates procuring three to four times as much water per capita as the average municipality uses throughout the eastern states. The total capacity of the plant is therefore planned for 6,000,000 gals. per day and the water consumption during certain hours of the day has already reached this large volume.

A Typical Western Case

Many cities through Idaho, Washington, Oregon, Utah, Montana and other western states procure their water supply from irrigating canals similar to Twin Falls and these cities using such source of supply have found the canal water so contaminated as to be unsafe to drink without purification. This contamination usually arises because of drainage into the irrigating canals from farmhouses and from discharging of raw sewage without treatment into the streams. The conditions in Twin Falls are therefore quite similar to those in many other of the western municipalities, and the successful handling of this same problem at Twin Falls may be of interest and helpful to the municipalities of many other western states that must sooner or later solve this same question of providing an absolutely safe water for domestic and commercial needs.

Filter Plant

At Twin Falls the canal supply is at sufficient elevation above the city to permit of a gravity plant; the water flows from the canal through a 24-in. pipe line, measured with a Venturi meter into a receiving basin. The level of the water in the receiving basin is regulated by an automatic float valve which maintains a constant elevation over the filter. The canal at Twin Falls, as is usual with canals, must be emptied at certain seasons of the year for repairs, and at times the water in the canal is low, and to provide for this emergency low service pumps are utilized for lifting the water from the canal at these low stages into the settling basins. A large settling basin of approximately 20,000,000 gals. capacity has been provided for storage of water during times of repair. The filtration system is no different than other purification plants that have been described quite fully in engineering periodicals,



MACHINES FOR DRY-FEEDING SULPHATE OF ALUMINA, TWIN FALLS, IDAHO, WATER PURIFICATION PLANT.

except that advantage has been taken in this plant of all of the modern improvements and methods utilized in handling of the water.

Sulphate of alumina is used as a coagulate and this is fed through dry feed machines in a pulverized condition, feeding through a hopper and delivered to the water as a ribbon of chemicals over a small wheel. In order to insure a thorough mixing of the sulphate, baffle walls are so arranged as to give the water a travel of 1,600 ft., passing up and down through these baffle walls. After this thorough mixing the water passes to two concrete lined settling basins, where approximately 85 percent of the sediments and impurities are removed from the water. After the settling basin treatment the water passes over a weir to a concrete flume, flowing on to the sand filters. Six of these sand filters are provided, with a normal capacity of 1,000,000 gals. each, making a total of 6,000,000 gals. per 24 hours. Each of these filters is provided with marble top operating tables with hydraulically operated

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EXTERIOR VIEW OF TWIN FALLS, IDAHO, WATER PURIFICATION PLANT. FILTER HOUSE IN FRONT, HEAD AND CHEMICAL HOUSE IN REAR.

valves, and water from each filter passing through a Venturi meter with a recording equipment, so that the rate of each filter can be easily observed. On the operating table each filter also has a control stand so arranged as to indicate the time when the filter requires washing, which will be shown by the loss of head of each filter recorded on the operating table. The washing of the filters is accomplished with a wash meter pump of large capacity. The plant is provided with a master controller which forces the plant to operate in proportion to the demand of the city, which is one of the latest improvements in purification equipment and is very desirable from a standpoint of an economical operation.

A Modern Plant

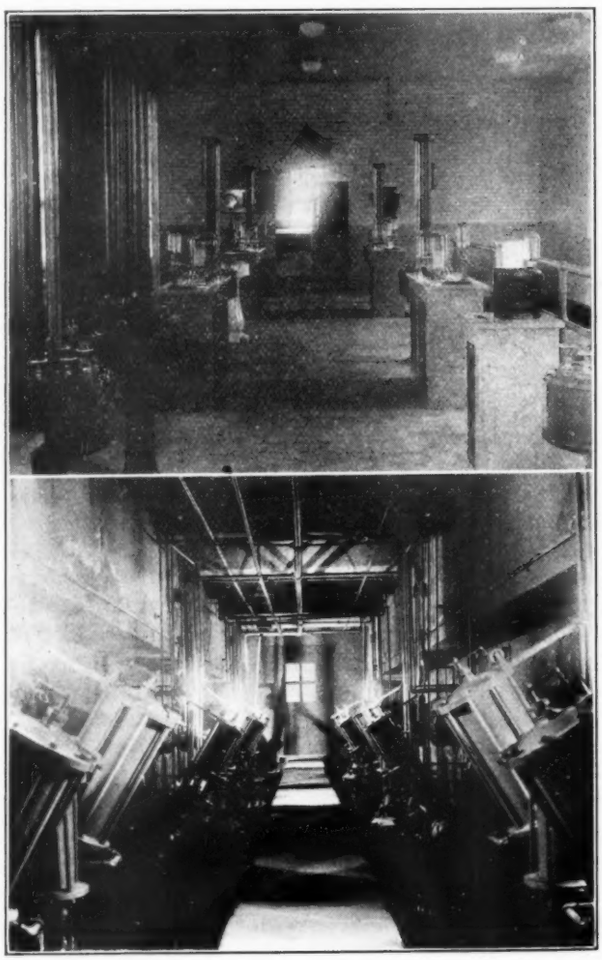
Nothing has been left undone to make the Twin Falls purification plant the most modern plant in the United States. The purification plant delivers the water to the city free from turbidity, odor, color, and tests made show an average of 98% of all bacteria removed. The design of the purification works, both interior and exterior have been of a character that is pleasing to the eye and makes the entire plant one of the show places of the municipality. The water after purification flows to the city by gravity through a line 2½ miles long and 24 ins. in diameter. This gravity flow line is of California redwood pipe, the line being built of continuous stave pipe assembled in the trench. The purification plant is on a hill 190 feet above the city and is delivered to the municipality at a pressure in the mains throughout the business district of 70 lbs. per square inch.

Cost

For the building of the purification plant and improvements in the distribution system, Twin Falls voted a bond issue of $375,000. While this bond issue may seem high for a city of 10,000, yet it is less than one-half the amount of an estimated cost of a former gravity supply which had been considered, but for which the voters failed to ratify a bond issue. The entire purification plant, settling basins, and pumping equipment is so arranged that additional units may be added as the growth of the city justifies an increase in capacity.

Meterage

Before the plant was turned over to the city the Consulting Engineers, Burns & McDonnell, Kansas City, Mo., through their resident engineer, C. E. Painter, made an investigation of the meter situation, with a view of recommending the complete meterization of the entire city. The result of this investigation showed only 38 meters out of 1800 taps and the City Commissioners immediately ordered 500 meters and a price contract was made for future orders and within a short time Twin Falls will be 100% metered. This report of the engineers showed that the present purification plant would have to be extended and enlarged within five years unless prompt action was taken toward curtailing the unnecessary waste of water. Between 11.00 A. M. and 1:00 P. M. and from 5:00 to 7:00 P. M. water in Twin Falls was used at the rate of 7,000,000 gal. per day. It will, therefore, be seen that the plant had to run in excess of its normal 6,000,000 gal. capacity during these peak load hours, but with the restriction on the waste of water the present capacity of the plant should be sufficient for 15 to 20 years. An investigation was made of 24 customers using water on a flat rate. Leaky plumbing was found responsible for the largest loss in these 24 hours and meters were installed on these 24 users and a later investigation was made to determine the result and it was discovered that $196 was the revenue produced under the flat rate, while under the yearly rate with meters a revenue of $303.88 was produced and of these 24 customers 50% were being overcharged and the other 50% were being presented water free of charge. This was, of course, not equitable or just. The total income was increased 55% and much water was saved to the municipality. The City Council and the Mayor co-operated with



INTERIOR VIEWS OF WATER PURIFICATION PLANT AT TWIN FALLS, IDAHO.
UPPER VIEW: OPERATING FLOOR. LOWER VIEW: FILTER GALLERY.

the Consulting Engineers in carrying out the recommendations and at Twin Falls, as it should be in other municipalities, it was felt unwise to operate a modern water purification system and then permit the water to be wasted through illegitimate use.

The entire water system at Twin Falls was designed and supervised by Burns and McDonnell, Consulting Engineers, with C. E. Painter as their resident engineer. The general construction contract was awarded to Heuser-Packard Construction Co. and a local contractor, Mr. Haskins laid the mains and distribution system. The filtration plant was erected by the Pittsburgh Filter and Eng. Co. of Oil City, Pennsylvania.

The accompanying cuts illustrate some special features of the plant. It frequently happens that municipalities will procure a model purification plant and then leave the operation to an inexperienced person and poor results will often follow. However, at Twin Falls the city officials procured a trained filter operator in J. E. Byers, who has recently returned from the army service, and under his operation the purification plant receives constant attention, daily analysis of water and the consumers are assured of uniform results with a minimum amount of chemicals and safe water free from dangerous bacteria.

ELECTRICALLY OPERATED WATER WORKS PUMPING PLANTS IN INDIANA

By G. C. Blalock, Instructor in Electrical Engineering at Purdue University, Lafayette, Ind.

According to available records, there are 206 public water works systems in the State of Indiana. Seventy-six of these, more than one-third, are operated partially or wholly by electricity. During the past winter and spring, 27 of these plants were visited by members of the Engineering Experiment Station staff of Purdue University with a view to ascertaining the present status of electrical operation of such plants. The results of this investigation, with other pertinent data, will appear shortly in the form of a bulletin issued by the Experiment Station.

Observed Conditions

The plants visited supply water to communities ranging in population from 500 to 25,000 and were found to be operating under a variety of conditions.

Fifteen plants used some form of elevated storage—tank, standpipe or reservoir; six were provided with compression tanks, the pressure being automatically controlled by pressure gage relays, while the remaining six had no provision for storage, but maintained direct pressure by continuous operation of the pumps. This probably represents in a general way the distribution as to types of plants over the state as a whole.

About 20 percent of the plants visited made use of deep well pumps—air lift or displacement. The remainder used surface pumps, though in many cases the pumps were placed in pits from 4 to 15 ft. below ground level in order to reduce the suction lift.

Drilled Wells

The most commonly encountered source of water supply was the drilled well, 6 to 10 ins. in diameter and from 100 to 300 ft. in depth. In a few cases the supply came from streams or spring-fed reservoirs, but these were rather exceptional. The water from wells appears to be,

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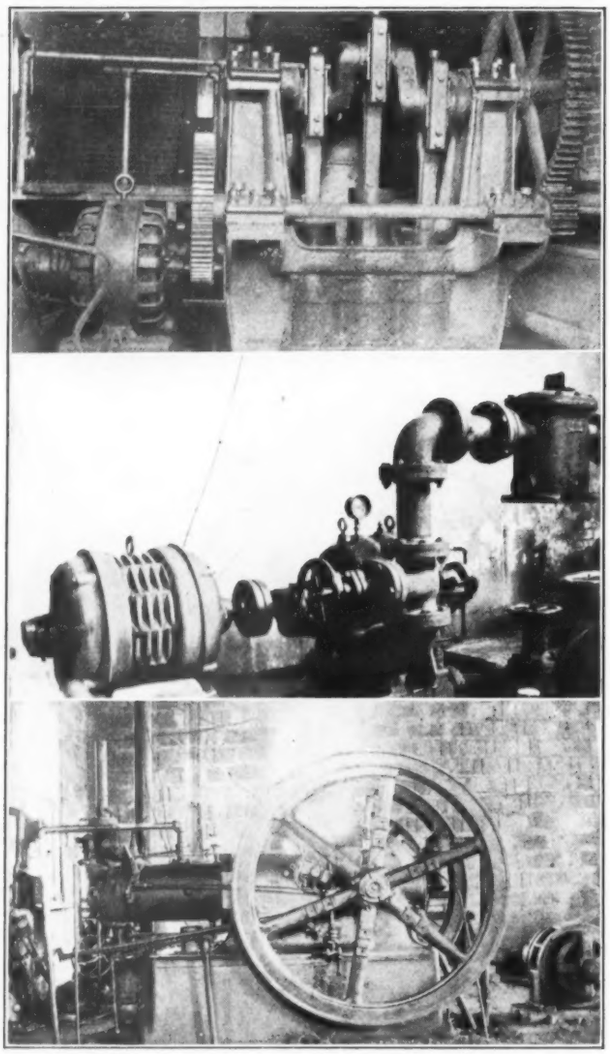
in general, clear and pure, requiring no outlay for purification equipment. In most localities the water stands from 10 to 20 ft. below ground level, but in a few places the water flows to the pump under sufficient head to eliminate entirely the necessity for priming.

Types of Pumps

Centrifugal pumps and triplex displacement pumps were encountered in about equal numbers and the plant which contained neither of these types was exceptional.



ELECTRICALLY OPERATED PUMPING PLANTS IN INDIANA.

Top View: Goulds Triplex Pumping Unit at Plymouth. Motor Westinghouse 15-h.p., type HF. Elevated tank storage, manual control.

Center View: Domestic service set and water meter at North Manchester; 25-h.p. Motor Westinghouse, type CS, two-stage Alberger pump, 380-g.p.m., 160-ft. head. Automatic operation standpipe storage.

Bottom View: The 20-h.p. General Electric, type KT motor and oil engine it replaced at Williamsport.

One rotary pump was observed, handling the second stage of a 2-stage system, and the city of Lafayette has three direct-connected motor-driven propeller pumps forming the first stage of a 2-stage system, the second being handled by steam pumps. These, however, are held for emergency use, the first stage pumping being normally done by air lift. Also, in one case the first stage was handled by motor-driven deep-well pumps and the second stage by steam pumps. In 75 percent of the plants inspected, however, the single stage system was used.

Alternating Current Used

Alternating current energy was utilized in practically all cases, either because direct current was not available or because the alternating current motor is cheaper, more rugged and requires less attention. Various types of alternating current motors were found to be in use, the choice depending chiefly upon type of pump to be driven. In most cases the available energy supply is 60-cycle, 3-phase current, and the choice lies between the squirrel cage and the wound rotor types of induction motor, the former being used for driving centrifugal pumps, where the starting load is light, and the latter for driving displacement pumps, where the starting load is relatively heavy. Exceptions were noted to this general rule, and in one case synchronous motors were found giving very satisfactory service. Single phase, 25-cycle motors were encountered in one plant, the energy being obtained from an interurban railway transmission line which passed through the town.

Water Pressures

The pressures in use for domestic service were found to range from 25 to 90 lbs. per sq. in., the average being about 40 lbs., corresponding to a head of 92 ft. In many cases provision is made for raising this pressure for fire-fighting purposes to 90 or 100 lbs., by cutting off the storage and bringing a special high-pressure unit into service. It is not uncommon to find steam pumps used for securing the extra pressure needed for fire service, though the motor-driven fire service pump is popular in localities where auxiliary steam equipment would be expensive to provide and maintain. There appears to be a growing sentiment in favor of securing the extra pressure by using a portable pump at the location of the fire, rather than by boosting the pressure over the whole system, thereby making both mains and plumbing liable to damage or even complete failure at a time when such failure would be most serious. This method also eliminates the extra demand for water at service connections during the high pressure periods when the greatest possible supply should be available for fighting fire.

Pump Capacities

The average pump capacity provided for domestic service appears to be about 200 gals. per minute per 1,000 population, but this figure is not of very great value, since the capacity required depends very largely upon local conditions and may vary widely for towns of the same population. Also, the system used has considerable influence upon the pump rating. A direct-pressure system must have sufficient capacity to supply the peak of the load, while in a storage system the pump needs to supply only the average demand, anything above this being drawn from the storage. The tendency is to provide too much rather than too little capacity, in order to be on the safe side and to provide for future requirements. The pumping units designed for special fire service average about 250 gals. per minute pump capacity per 1,000 population. These units also provide reserve capacity for abnormal demands other than for fire service.

Reported Conditions

Town officials and operating men expressed themselves almost unanimously as well pleased with the results obtained through use of electrically operated equip-

ment. Appreciation of the greater convenience and decreased operating expenses was especially marked in places where the pumps were previously steam driven. One plant was visited in which steam operation had been resumed after a trial of electric operation, but no one available at the time could give an adequate reason for the dissatisfaction with the electric drive.

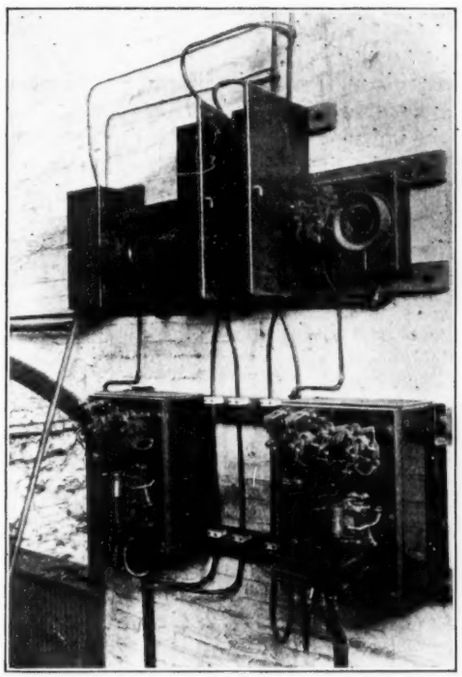
Another case of dissatisfaction was encountered where a direct-connected, motor-driven centrifugal pump was giving unsatisfactory service, though no blame was placed upon the motor itself. The pump was obviously not designed for the conditions under which it was working and the result was an energy consumption very greatly out of proportion to the work done. Plans were being made to replace the centrifugal with a triplex pump, though it appears likely that a change in impellers would have accomplished the same result. This serves to emphasize the necessity for using great care in specifying a centrifugal pump for a given application, in order that its characteristics may be suited to the work it is expected to do.

Minor Troubles with Equipment

Numerous cases of minor troubles with the equipment were reported. Of those directly chargeable to electric operation the only ones of serious import were those due to lack of adequate protective devices between motor and line. Some of these involved no serious consequences, while others involved considerable expense and inconvenience, as well as fire risk. It would appear that the necessity for adequate protection of the motor and control circuits is not generally appreciated. The cost of such protective apparatus is not great and will soon be repaid through decreased repair bills and greater reliability of the equipment. Troubles were reported due to lack of reliable low voltage and no-voltage cut-outs, and also to lack of proper protection against lightning. Good lightning-arrester equipment, properly installed, is absolutely essential where power is secured from a transmission line, and is the only means of preventing damage from this source, which may vary all the way from a breakdown of insulation in one or more coils to destruction of the entire electrical equipment.

Next to having the apparatus itself it is of importance that attendants should understand the significance of the protective devices. One plant was visited where no voltage protection was provided, but a former attendant had decided that by wedging the starting handle in the full-on position he could start the pump from the power station and save himself a half-mile walk. Unfortunately, the motor windings did not survive the initial experiment, but had to be entirely replaced.

The most frequent source of trouble other than electrical appeared to be due to freezing in severe winter weather. Bursting of pump cylinders was reported in numerous instances. In some cases these breaks had been repaired by welding, in others the cylinder had to be replaced. Troubles from this source can be charged only to neglect in providing some means of keeping the temperature sufficiently high to prevent freezing.



PRESSURE GAUGE RELAYS AND AUTOMATIC CONTROLLERS FOR TWO SINGLE PHASE 15-H.P., 25-CYCLE MOTORS DRIVING TRIPLEX PUMPS AT NEW CARLISLE, IND.

Cheap Equipment Causes Trouble

The installation of cheap equipment invariably results in troubles due to excessive wear and breakage, and poor judgment in the selection and use of equipment augments the difficulties along this line. In one plant the first stage was handled by an air lift and the second by a cheap rotary pump. The latter was driven at such high speed that it handled water faster than the air lift could supply it, so a portion was by-passed and pumped over again. In

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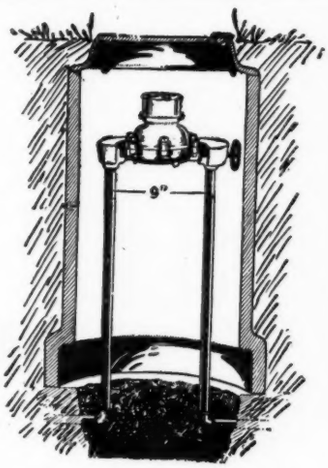

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addition, the wear on the impeller was so great as to necessitate its renewal two or three times each year.

Troubles due to flooding sometimes occur in plants having the pumps located in pits. Unless the motor windings have been thoroughly water-proofed they are sure to be more or less permanently damaged, with consequent shortening of their useful life, although the damage may not be such as to require immediate rewinding.

Improper alignment of pump and motor causes undue wear and results in decreased efficiency and increased maintenance cost. The same cause sometimes results in broken rods in case of deep-well pumps.

Corrosion and rapid wear due to sediment in the water being pumped were reported in one or two instances.

Meterage

The practice of selling water by meter appears to be rapidly superseding the old flat rate system. Of more than 13,000 service connections reported, nearly one-third were metered. Four systems were entirely metered, while only two had no meters at all. Many towns are changing over to the meter system as rapidly as circumstances permit, and expect to have all connections metered within a year or two.

Only six of the towns visited had provision for metering the pump discharge, despite the obvious advantage of having this means of checking the performance of the pump and motor. With a watt-hour meter on the input side of the unit and water meter and pressure gage on the output side, the duty and over-all efficiency may readily be determined at any time and any marked drop detected and accounted for. A centrifugal pump needs particularly to have its performance checked to avoid the marked drop in efficiency which occurs when the impeller is not properly designed for the conditions under which it is working. The substitution of an impeller of slightly different design may effect a saving which will pay for both meter and impeller within a comparatively short time.

Operating Records

It was found rather difficult to obtain accurate records of plant operation and costs, particularly in the smaller towns. Combined power and pumping plants frequently do not provide separate meters for measuring the energy supplied to the pump motors nor divide the operating costs equitably between the power and pumping departments of the plant. Where energy is obtained from sources not owned or controlled by the interests operating the pumping plant, the meter provided often includes the energy used for street lighting, station lighting and heating or other purposes, and, as previously mentioned, it is not often that provision is made for measuring and recording the amount of water pumped. The data obtained therefore involves estimates in many cases, and should be considered as indicating plant performance in a general way only.

Data for calculating energy consumption per 1,000 gals. of water pumped was obtained for 14 towns. In kilowatt-hour per 1,000 gals. this energy consumption ranged from a minimum of 0.20 to a maximum of 3.28, giving an average value for the 14 towns of 1.31.

Since there is considerable variation in the total head against which these pumps are working, a better measure of performance may be obtained by reducing the figure given for each plant to a basis of 100 ft. total head. This gives values ranging from 0.125 to 1.96, with an average of 0.90 kw.-hr. per 1,000 gals. per 100 ft. head.

The operating cost per 1,000 gals. was found to range between 0.88 and 16.83 cts., with an average value of 4.97 cts. Reduced to a basis of 100 ft. head, this average becomes 3.74 cts. per 1,000 gals. per 100 ft. head.

Tests

Two plants equipped with meters for measuring the pump discharge were selected, and tests were run, with two objects in view: First, to determine the duty and over-all efficiency of the pumping unit, thus obtaining a basis for figuring energy costs per unit discharge; and second, to determine the nature of the power demand and thereby establish the degree of desirability of pumping loads from the central station point of view. The test in each case extended over a period of 24 hours, and in addition to kilowatt-hour and water meters, a graphic recording wattmeter was used for measuring and recording the power demand.

The unit tested in the first plant consisted of a 2½-in., single stage, 175-gal. per minute, centrifugal pump, driven by a 15-h.p., squirrel-cage type, induction motor, pumping continuously against the direct pressure of the mains. A total pumpage of 11,900 cu. ft. was observed—an average rate of 61.8 gals. per minute—against a pressure of 40 lbs. per sq. in., with input of 9.38 h.p., giving an over-all efficiency of 16.7 percent. Estimates based upon pipe friction tables give about 10 ft. loss of head in elbows, valves, meter, etc., between the pump intake and the point at which the pressure gage was attached to the main. Including this loss of head raises the efficiency about 2 percent. This still gives a very low over-all efficiency, but it should be noted that the pump is discharging but little more than one-third its rated capacity, this resulting in the motor running at considerably less than its normal rating. Neither pump nor motor can therefore be expected to show very good efficiency. It is evident that this unit is not operating under the conditions for which it was designed, resulting in high energy consumption per unit output.

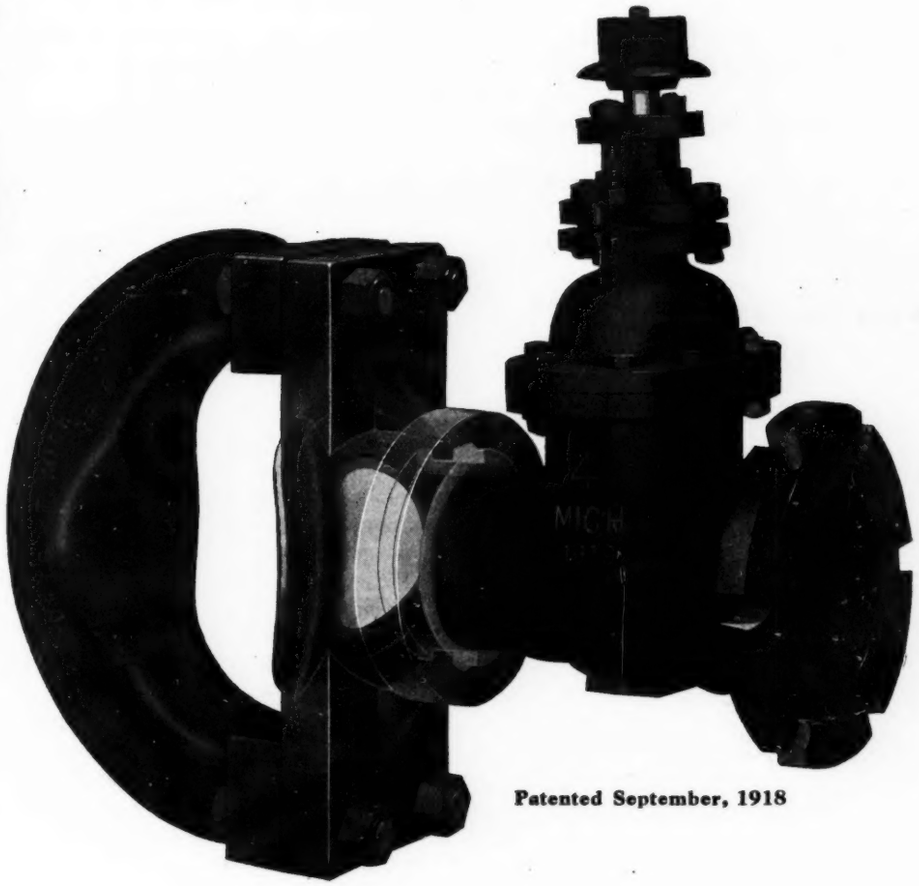
The unit tested in the second plant consisted of a 4-in., 2-stage, 380-gal. per minute, centrifugal pump, driven by a 25-h.p., squirrel-cage type, induction motor, pumping to mains, with standpipe storage, the frequency and duration of pumping periods being regulated by a pressure-gage relay and an automatic motor starter.

Three runs of approximately two hours each, at an average pressure of 55 lbs. per sq. in., gave a pumping rate of 350 gals. per minute, with an input of 32.25 h.p., showing an over-all efficiency of 38 percent. Estimated loss in head due to friction amounts, in this case, to about 35 ft., and inclusion of this loss as part of the total head raises the efficiency about 10 percent. The over-all efficiency in this case checks closely with manufacturers' estimates for this size and type of unit, and the unit is evidently well adapted to its work.

Conclusions

The conclusions arrived at as a result of investigation and study of the present status of electrically-operated pumping plants of Indiana may be summed up as follows:

1. Where local conditions have been carefully considered, the type and capacity of pump and motor which best suits those conditions intelligently selected, electric-



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ally-driven pumps have proven highly satisfactory; they have been found to be easily handled, convenient, reliable and economical.

2. While the motor itself is very unlikely to give trouble, and transmission lines have proven quite reliable, yet it appears advisable to provide some auxiliary source of power. The automobile-type gasoline engine appears particularly well suited to this purpose.

3. The energy consumption in properly designed plants may be expected to vary from 0.2 to 2.0 kilowatt-hours per 1,000 gals. per 100 ft. head, with 1.0 as a fair average.

4. The operating expenses for an electrically-operated plant are low—considerably below those for a steam plant and appreciably below those for an internal combustion engine plant.

5. The pumping plant load is a desirable one from the central power station point of view.

The foregoing paper by Mr. Blalock was presented before the annual convention of the Indiana Engineering Society, January 24, 1920.

DESIGN AND COST OF WATER SUPPLY DAMS AT JACKSONVILLE AND DECATUR, ILL.

By Samuel A. Greeley, Consulting Engineer, 39 West Adams St., Chicago, Ill.

The Jacksonville Dam

Jacksonville, one of the oldest cities in Illinois, has been contending with the water supply problem during nearly its entire existence; in fact, its difficulties in securing an adequate supply have been so often repeated that only a brief mention of them need be made here.

Originally a small impounding reservoir supplied the town, supplemented shortly after by another small reservoir formed by a low dam across the stream, from which the future supply is to be drawn. These two sources later proved insufficient and other means were sought from time to time. Wells in the Illinois river bottom lands did not prove a success, and finally some drift wells were sunk north of the town. The water from these wells, with the other sources, form the present supply. The quantity is inadequate and the quality unsatisfactory.

The present population is about 16,000, and, in addition, there are several public institutions which bring the total population up to about 19,000. The city is fully metered and has an average daily consumption of about 1.25 million gallons per days. The maximum demands are modified by a storage reservoir holding a day's supply and located high enough to provide a gravity supply.

Jacksonville Impounding Reservoir

Upon investigation, several possible sources of supply were apparent: impounding reservoirs on any one of four streams in the vicinity and enlarging the present well system. All factors considered, it was finally recommended that a new impounding reservoir be formed by constructing a dam across the south fork of the Mauvaiseterre creek, adjacent to the old pumping station. The total tributary area is about 27 sq. mi., 2½ sq. mi. of which supplies a small reservoir incorporated in a park.

The new reservoir will have a maximum depth of 14 ft. to the spillway, flood approximately 240 acres with water at the crest elevation, and contain about 430,000,000 gals. The available draft will average 1,500,000 gals. per day and 2,000,000 gals. per day in all but the very dryest years.

Should future demands require more water, additional storage may be obtained upstream or an impounded supply from an adjacent watershed may be devoloped and pumped over a low divide.

Design of Jacksonville Dam

The city voted a bond issue to finance the project in accordance with the recommendations. The length along the crest of the earth section is about 600 ft. and the height is 22 ft. The spillway is 160 ft. long and is set 8 ft, below the top of the earth embankment. Provision for a flood flow of 4,500 sec. ft., with a 4-ft. flow over the spillway, is made, which is equivalent to 167 sec. ft. per square mile. The spillway is practically a submerged weir with discharge into a sloping channel. The channel is narrowed to 65 ft. wide at the lower end, thereby using up a portion of the velocity head, and is lined with 6 ins. of concrete on gravel to prevent erosion from the high velocities.

Bids were taken in April, 1919, and a contract for $58,887 awarded to John T. Walbridge Engineering and Contracting Company, of Chicago.

The material in the dam is compacted clay taken from excavation in the side hill, which excavation forms the spillway channel. A concrete conduit and gate house are located near the center of the earth embankment. The concrete conduit was used to take care of the ordinary stream flow during construction and is to carry the pipe lines to the pumping station. There were no floods to speak of and the work was carried through with practically no delay. The dam is now finished and water stands within about 4 ft. of the spillway. Bids for a filter plant will be taken in a few weeks.

Cost of Jacksonville Dam

The final costs on the dam are as follows:

1.	Earth fill, 28,453 cu. yd. at $0.50	$14,226.50
2.	Stripping 3,104 sq. yd. at $0.60	1,862.52
3.	Excess spillway excavation, 3,517 cu. yd. at $0.40	1,406.80
4.	Core wall, 1,666 cu. yd. at $2	3,331.80
5.	Conduit and gate house	9,300.00
6.	Slope paving, 4,000 sq. yd. at $2.50, 1,123 sq. yd. at $2	7,754.00
7.	Spillway, $21,000, less 5,313 cu. yd. at $9	16,218.30
		$54,099.92

Cost per million gallons of storage capacity equals $12,560.

The Decatur Dam

In Decatur the need for additional water supply has been recognized for the last 8 or 10 years. The extreme dry weather flow of the Sangamon river there is almost nothing. The problem was to remedy this condition by the construction of a storage reservoir.

Preliminary investigations and action by the city council had settled the location of the proposed dam. The storage required, the type of dam and spillway capacity were items requiring extensive study.

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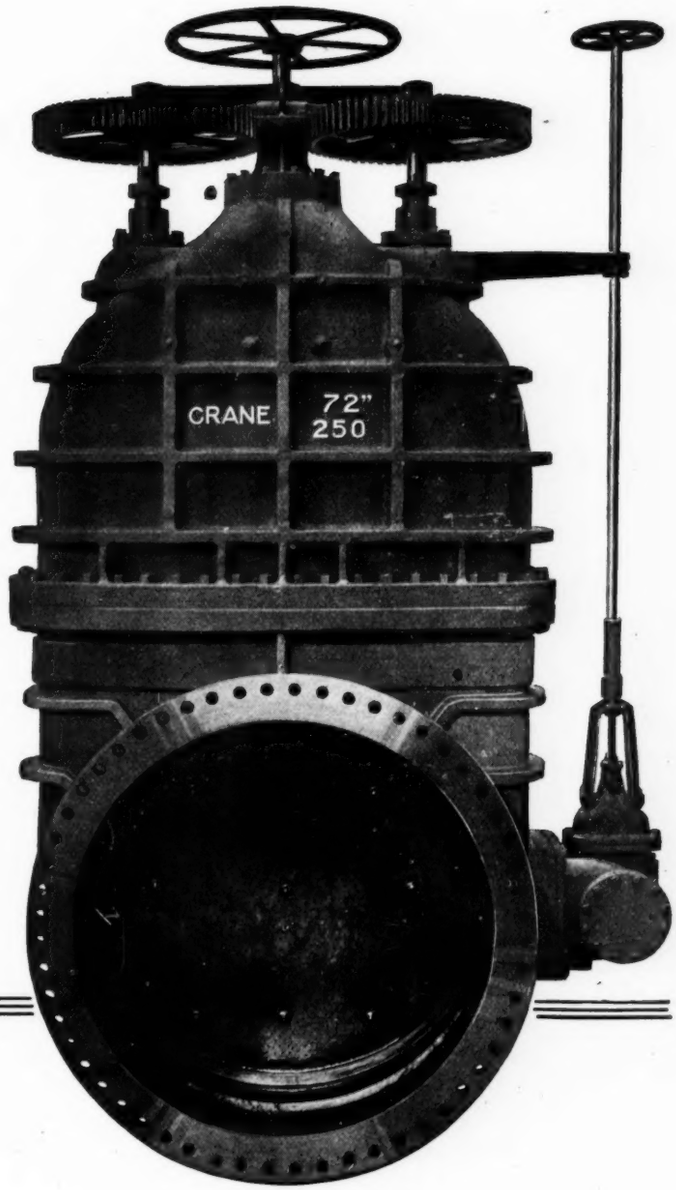
This valve has two bronze spindles, upon which the huge gates (weighing 4½ tons) may be readily raised and lowered by the 42-inch hand wheel, operating in connection with the gears. The gates are bronze-faced and travel on bronze rollers on bronze tracks in the valve body.



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A thorough investigation of the entire problem was made and a considerable amount of field work done. All of the available data on flood flows in Illinois and the surrounding states were examined. The maximum flood on record in the Sangamon river at Decatur occurred in 1913 and was found to be approximately 21,500 sec. ft., equivalent to 25 sec. ft. per sq. mi. from the tributary area of 862 sq. mi. Assuming a 5-ft. depth overflow, a spillway 500 ft. long would be required. The earth embankments will be 13 ft. above the crest, so that the spillway will safely pass a considerably greater flood.

The amount of storage required was determined from local conditions, which made it feasible to provide a total storage of about 9,000,000,000 gals., yielding an average daily flow of about 40,000,000 gals. per day.

Design Features of Decatur Dam

Various types of sections for the spillway were studied, and it was finally decided to adopt a concrete gravity section. Borings indicate a reddish brown clay for the first 10 ft., with alternating layers of gravel and sand for 10 to 40 ft. Below this is an 8-ft. layer of clay, and below this more sand.

The dam is designed to reduce the velocity of percolation and thereby prevent undermining by the provision of a sufficient length for the enforced percolation. This is accomplished by means of steel sheet piling, a broad base, and upstream and downstream aprons. Under the spillway section round bearing piles, spaced 3.25 ft. center to center, are used. The crest of the spillway is 500 ft. long and 28.5 ft. high, while an additional 2 ft. of storage may be obtained by a movable crest. The foundations are also designed to stand an increase of 5 ft. in the height of the spillway. Two 9-ft.x14-ft. flood gates and a 4-ft.x 4-ft. flushing gate are incorporated in one end of the spillway. There are also two 36-in. water pipe connections, one of which is reserved for future use.

The earth embankments are 13 ft. above the crest, as previously stated, and are 1,200 ft. long, being cut approximately in two by the concrete section. The effect of the reservoir formed by this dam will be noticeable 12 or 15 miles upstream.

The cost of the entire project is estimated at $1,250,000, including land. Bids for this work will soon be advertised so that the construction may get an early start this spring.

The foregoing paper by Mr. Greeley was presented at the annual meeting of the Illinois Society of Engineers.

WATER SUPPLY SHORTAGE AT NORFOLK, VA.

It is not often that a large city experiences a water shortage but such a case has arisen in Norfolk, Va. That city was visited on Jan. 15, 1920, by engineer Robert C. Dennett for the purpose of investigating the reported shortage of water and its effect on fire protection. Mr. Dennett made the following report on Jan. 19, of his findings to the National Board of Fire Underwriters:

The city obtains its supply from a series of lakes, situated 5 to 10 miles east of the city, pumped, filtered and repumped directly to the distribution system. The normal storage in these lakes is about 2,000,000,000 gallons. Due to an abnormally low rainfall in 1918 the storage in the lakes was considerably below normal last July and since that time the rainfall has been very slight, so that at the date of this inspection the total storage was estimated to be 300,000,000 gals.

The water department has installed electric or gasoline driven centrifugal pumps at various points, which discharge into canals or pipe lines, so that all of the water in the various lakes can reach Lake Wright, on which the pumping station is located. On Jan. 16, the clear water basin, capacity 3,000,000 gals., and the coagulation basin, capacity 3,500,000 gals., were full, and Lake Wright, which is adjacent to the coagulation basin and feeds it by gravity, contained an estimated 30,000,000 gals. Considerable ground water is reaching the lakes, an amount estimated at from 5,000,000 to 8,000,000 gals. a day. Arrangements have been made so that in extreme emergency salt water can be pumped into the lakes.

The normal consumption for the city is about 12,000,000 gals. a day. In order to conserve the supply the normal pressure of 50 lbs. at the pumping station was reduced on December 4. Under present operations a pressure of 8 lbs. is carried from 10 P. M. to 6 A. M., 20 lbs. from 6 to 7 A. M. and from 5:30 to 6 P. M., 12 lbs. from 8:30 A. M. to 12 noon, from 1 to 5:30 P. M. and from 8 to 10 P. M., and 40 lbs. from 7 to 8:30 A. M., 12 noon to 1 P. M. and 6 to 8 P. M. At 1:30 P. M., on Jan. 16, the pressure was 9 lbs. at a hydrant at fire headquarters. Charts from a recording gage at the city hall in the congested value district show a minimum pressure of 8 lbs.; the normal pressure would be about 30 lbs. The city is practically level and pressures in other parts would not be lower than given above.

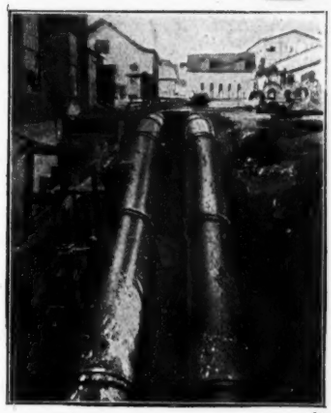
The pumping station receives all alarms of fire on a gong over a fire alarm circuit; telephone is also provided. On first alarms additional pumps are primed if necessary and on second alarms or special calls pressure is immediately increased to 45 lbs. The result of lowering the pressures has been a decrease in consumption to about 7,000,000 gals. a day.

The water now has a slight brackish taste and although tests by the city show the water to be safe there is some objection to its use for domestic purposes. The city is therefore hauling water in tanks and sprinkler carts from private supplies and distributing it to those who wish it.

Work has been started on an emergency supply from Berkley. A 14 in. submerged main crosses the river from Portsmouth to Berkley, supplied from Lake Kilby. From the terminus of this line a 16 in. main is being laid to the bridge to Norfolk, from which point a 20 in. will be laid to Water and Main Streets. Two 2,225,000 gal. electrically operated pumps will be installed at the terminus of the 14 in. line. Pipe and pumps are on hand, work is under way, and it is expected that it will be completed in three weeks. From 2,000,000 to 3,000,000 gals. a day will be available from this source.

For a temporary supply it is planned to start work

Elevating and Conveying Abrasive Material



The greatest copper reclaiming plant in the world is that of the Calumet & Hecla Mining Co., on the shores of Torch Lake, an arm of Lake Superior. Fifty million tons of mill tailings, which have accumulated here during the past 50 years, are now being dredged and pumped out through the two lines of

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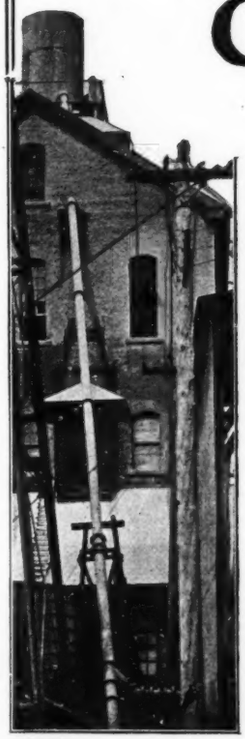

shown here, at the rate of thousands of tons daily, to the tanks in their ammonia leaching plant. No other pipe has yet been found to withstand this severe service so well.

At the left is shown a line of 10-inch Cast Iron Pipe conveying gas-house coke, in 8-inch lumps to fines, from a 7,500-ton silo to the top of grinding plant at the works of the Canada Carbide Co., Shawinigan Falls, Que. This is a pneumatic system, in which the material is conveyed a horizontal distance of 600 feet, with a vertical lift of 105 feet. The capacity is 15 tons of coke per hour with a velocity of 10,000 feet per minute. At last reports (August, 1919) this pipe showed no signs of wear after having been in service about two years.

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at once on a 20-in. main, laid on the surface of the ground, 9 miles long, from Lake Drummond. It is expected that within 90 days a supply of 8,000,000 gals. a day will be available to the city lakes.

On February 17, a bond issue of $6,000,000 for a new supply will be voted on. Plans are now being made and it is expected that work will start within 30 days. It is proposed to lay a 36 in. line to the city from Lakes Phillips and Burnt Mills, 18 miles away, to build a reservoir at the lakes, with an average depth of 12 ft. and a capacity of 3,100,000,000 gals. This will give a supply of 15,000,000 gals. a day, with further development possible. Water will be pumped and will enter the distribution system at a point opposite where the present supply enters.

The city officials appear to be well aware of the importance of maintaining adequate fire protection and are now doing everything that can reasonably be expected along these lines. They state that under all conditions enough water will be maintained in storage at the pumping station to meet the requirements of any fire. The pressure throughout the city is, of course, much below normal throughout most of the day, and this condition will continue so for some time unless there is a rainfall, but enough water for a first stream is available at any hydrant, and with the electric pumps in service, additional pressure can be obtained in two or three minutes upon call of the fire department, so that as long as the means of transmitting alarms to the station are in service and are promptly utilized when necessary for increasing the pressure, the situation in regard to fire protection cannot be considered critical.

CONCRETE IN WATER WORKS CONSTRUCTION

To the Editor: We were, of course, greatly interested in reading the article by Mr. A. C. Irwin, entitled "Concrete in Water Works Construction," published in your November, 1919, issue.

We are always pleased to see our work mentioned and illustrated in the engineering press, and we are much gratified at the general treatment of the subject in this article. We do feel, however, that in some respects the comparison made between multiple arch dams and the buttress and slab type of dam was so worded as to appear unfairly disadvantageous to the latter type.

What we mean can be shown most clearly by quoting from the article. On multiple arch dams it says:

> Some very high dams of the multiple arch type have been constructed, and plans are now being prepared for one in California which will have a height of considerably over 100 ft.

In a later paragraph the following statement in regard to the buttress and slab type appears:

> This type is especially adapted to long and low dams.

We fear that your readers will infer from this that the latter type, which is, of course, the one with which our name has been chiefly connected, is not adapted to high dams. In order to correct any such impression we are taking the liberty of writing to you and calling attention to the fact that several Ambursen dams higher than 100 ft. have actually been built. Among these are:

The dam on the Jordan river, British Columbia, for the British Columbia Railway Co., 115 ft. high and 760 ft. long.

The dam at Douglas, Wyo., for the La Prele Reservoir and Ditch Co., 150 ft. high and 325 ft. long.

The dam at Comerio, Porto Rico, for the Porto Rico Railway, Light and Power Co., 125 ft. high and 440 ft. long.

The Guayabal dam of the U. S. Irrigation Service in Porto Rico, 115 ft. high and 1,200 ft. long.

In addition to these and other high dams actually built we have from time to time prepared in this office complete designs for dams up to heights of 300 ft. and more, which have met with the full approval of consulting engineers employed by the owners of the projects. We have no doubt whatever that the Ambursen type of dam construction can be successfully carried to greater heights than any other.

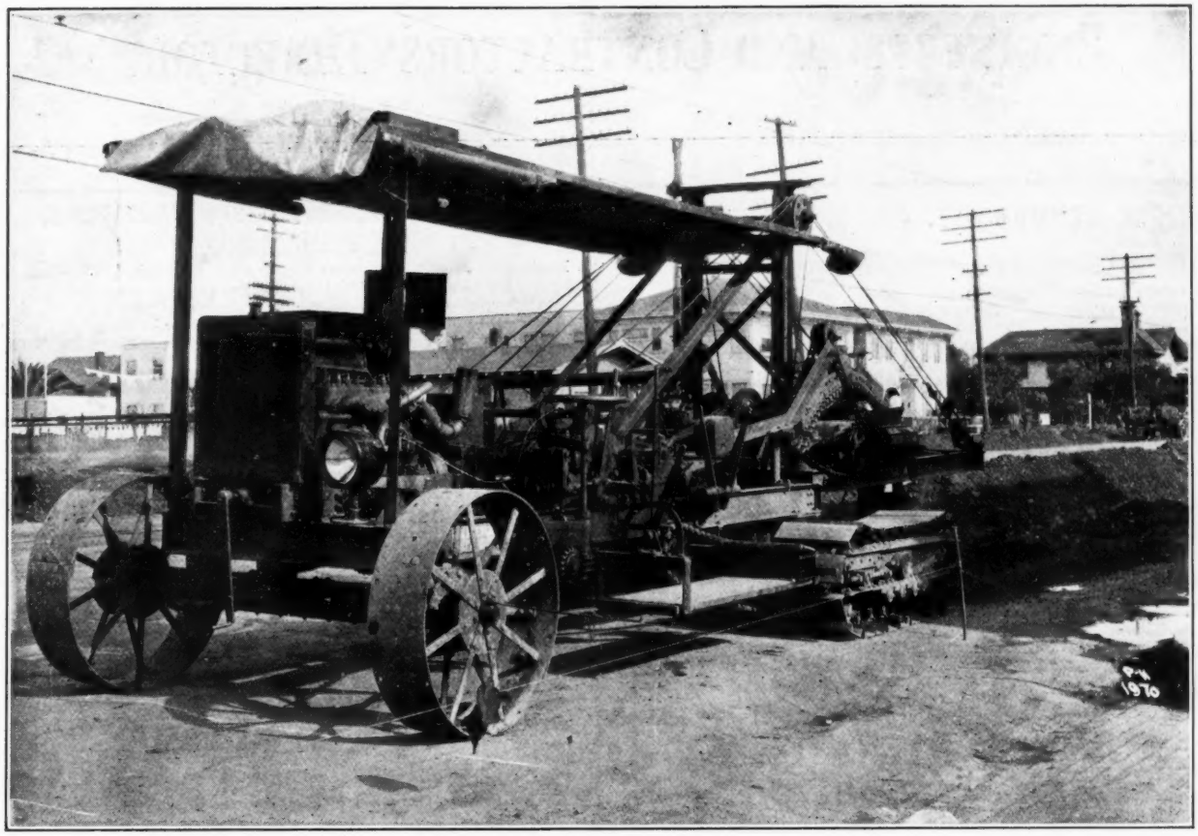
In the matter of adaptability to soft foundations there is also something that we should like to add to the article. On clay and earth foundations, such as many Ambursen dams have been built upon, a continuous foundation floor is often required in order to reduce the bearing pressure to a safe value. A comparatively close buttress spacing is obviously essential under such conditions, since long spans between buttresses would make the floor extremely expensive or even practically impossible to design. We have had to solve this problem for many of the dams we have built, and we believe that with no other type can it be solved as economically as with our own.

Very truly yours,

AMBURSEN CONSTRUCTION CO.,
By Robert C. Latimer, Chief Engineer.
New York City, Jan. 14, 1920.

CHLORINATION OF SCREENED SEWAGE

The city of Stockton, California, recently installed a new Reinsch-Wurl screen for the partial clarification of the sewage from the north part of the city, prior to disposal into the San Joaquin River. Several tests on the plant were run by the Bureau during the month, the effectiveness of the screen determined and considerable light thrown on sewage disinfection. The sewage here contains considerable wastes and its chlorine consuming power ranges between wide limits, which, however, may be fairly well gauged by the flow of sewage at the time. This observation made it possible to prescribe a sliding dose of chlorine as the flow varied. The tests also indicated that the relatively crude effluent of the Reinsch-Wurl screen required only slightly more chlorine for disinfection than the same sewage settled. The difference was so slight as to be not controlling in the selection of screening versus tankage treatment under the conditions prevailing at this plant, reports C. G. Gillespie, Director of the Bureau of Sanitary Engineering of the California State Board of Health.



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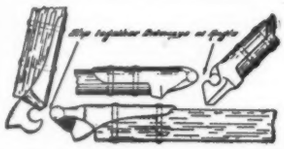

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CONSTRUCTION NEWS AND EQUIPMENT

USE OF CHARGING BINS AND PEBBLE WASHING PLANT SAVES MONEY ON CONCRETE ROAD CONSTRUCTION

Realizing the importance of adopting all the labor-saving devices possible on concrete road construction, the Board of County Road Commissioners of Wayne County, Mich., purchased a set of R. D. Baker Charging Bins for feeding a concrete mixer. The bins and the advantages of their use are thus described in the latest annual report of the Board.

These bins are mounted on a narrow-gauge industrial railway track and are attached directly over the loading skip on the concrete mixer. They have a capacity of 8 cu. yds. of pebbles or stone, sand and cement. Inclined tracks lead from the industrial railway track up onto the top of the bins, and industrial cars are pulled up the inclined track and dumped directly into the bins. This apparatus takes the place of 7 wheelers and 7 shovelers, who shovel the pebbles or stone and sand off from the grade after it has been dumped by the industrial cars and wheeled it into the mixer skip. The cars are dumped directly into the bins, and from the bottom of the bins the material is measured into the mixer skip by a rotating drum divided into segments.

This equipment was used upon two road jobs in the summer of 1919 namely, the Romulus-Belleville Road, and on Warren Road. This plan of charging a mixer has five distinct advantages:

1st. It insures clean aggregates, accurately proportioned by machine, free from dirt shoveled off from the grade.

2nd. It saves the cost of 7 shovelers and 7 wheelers, amounting, at the 1919 wage scale, to $70 per day, or reduces the labor cost about 10 cts. per square yard.

3rd. It makes it possible to operate immediately after a rainstorm even if the sub-grade is muddy, because no material has to be picked off from the grade, and the whole outfit is mounted on industrial railway tracks.

4th. It saves materials, as no material is dumped on the grade; the usual loss of about 10% of pebbles and sand is saved; everything that is hauled out on the grade goes into the mixer by mechanical means.

5th. The sub-grade is not cut up after fine grading has been completed, as is the case where from any cause motor trucks or teams are used for hauling.

The use of this device will be extended to other road jobs under control of the Board wherever feasible.

Pebble Washing Plant at Northville

Owing to the great possibility of being held up for shipments of pebbles and sand through railroad congestion and on account of the poor yard facilities at Northville, the Board decided to lease a gravel pit if a suitable one could be found and erect a small washing plant to furnish their own material for concreting the streets at Northville and the Fishery Road. They secured a lease for a very good gravel pit at Northville at 15 cts. per cubic yard in the bank, measurement to be governed by the number of cubic yards of concrete laid.

They erected a washing plant with a capacity of 200 cu. yds. per day on this property, graded the entrance and laid their industrial railway right up to the chutes from the washing plant bins.

The location of the pit is central to the road being built, thereby shortening the haul about one-half mile over the distance from the railroad siding if they had used commercial material. The lay-out of the gravel pit is such that it was much cheaper to arrange a yard at the pit than it would have been to unload from railroad cars.

A small stream fed by local springs furnished an abundant supply of water, which was pumped 1,000 ft. through 2 lines of 3 in. pipe to the washing plant by electric motor. A single line of 4 in. pipe would have been sufficient, but the Board used two 3 in. lines because they had the pipe in stock. The plant was operated by a small electric motor, making it comparatively simple in operation.

The cost of operation was approximately as follows:

4 teams	$8.00	$32.00
2 scraper holders	5.00	10.00
1 foreman	6.50	6.50
1 operator	6.00	6.00
2 car loaders	5.00	10.00
Motor rental	1.50	1.50
Electric current, est.		10.00
Total cost		$76.00

The average daily output was 200 cu. yds., which amounts to 38 cts. per cubic yard, plus 15 cts. for the cost of the material in the pit, making a total of 53 cts. per cubic yard for the material loaded in the industrial cars ready to haul. It will be noted by the above cost that the largest item is the teams loading the hopper which feeds the belt. This could be eliminated by the installation of a drag line bucket and hoisting engine, but owing to the short run which this plant will have it was not considered advisable to invest in so large an equipment.

Commercial pebbles cost $1.25 per ton f. o. b. cars at Northville, plus about 25 cts. per ton to unload into industrial cars, making a total of $1.50 per ton, or $2.25 per cubic yard. Comparing this figure with the cost of producing pebbles and sand in the Board's washing plant shows a saving of $1.72 per cubic yard. They will use approximately 10,000 cu. yds. of material out of this pit, which makes a gross saving of $17,200 over commercial material. The plant cost approximately $7,200 to erect. making a saving on the Northville job alone of $10,000.

This year the Board expects to operate the plant a few months to furnish maintenance gravel for their 24 miles of gravel road leading from Detroit to Plymouth and Northville. This road takes from 3,000 to 4,000 cu. yds. of gravel per year to properly maintain it, and the material

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which is produced at this washing plant is excellent for this purpose.

The Board also uses a considerable quantity of coarse sand in tarring cracks and expansion joints and slight holes in their concrete road surface. The sand produced at Northville is excellent for this purpose, and can be economically truck-hauled directly to a large mileage of the roads, effecting a still further saving.

THE AUSTIN COMBINATION DRAGLINE MACHINE

The Austin Combination Dragline Machine has attracted much favorable attention in the construction field because of its ability to perform a wide variety of construction operations. By using different booms, properly equipped, this one machine solves many earth and material handling problems.

According to the boom with which the machine is equipped, the outfit is suitable for performing any one of the following operations: Excavating, ditching, trench digging, backfilling, street and road grading, cleaning

AUSTIN COMBINATION DRAGLINE WITH COMBINATION BOOM AND "SKIMMER."

ditches, loading and unloading loose bulk materials and for general hoisting work; thus, it performs the functions of a dragline excavator, power shovel, clamshell, and skimmer bucket, crane and pile driver or puller. It is important to note that this machine is equipped to use the requisite attachments by simply changing the booms and buckets. No drums have to be added. The machine is

SHOWING HOW SHOVEL DIPPER IS ATTACHED ON AUSTIN COMBINATION DRAGLINE MACHINE.

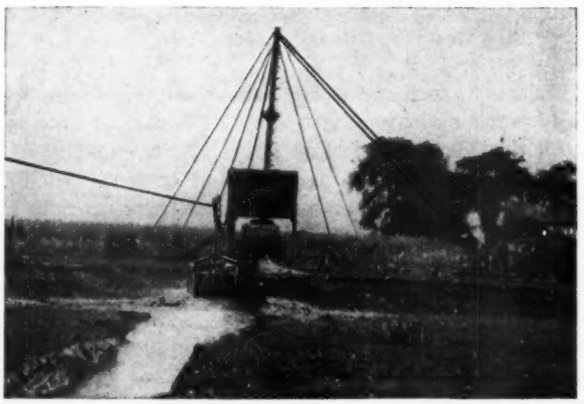
driven by internal combustion engine steam or electric power. The multipedal traction makes feasible operation over soft surfaces and the crossing of many bridges without the shorting that wheel traction would require. The

(Continued on Page 38)

Improved Way to Dig and Convey Materials

Why so many Sand and Gravel Producers, Highway Commissioners and Contractors use

Sauerman
DRAGLINE CABLEWAY EXCAVATORS



Small Sauerman Cableway operated by Double-Drum Belt Hoist driven by 20 h. p. traction engine. This outfit used by Illinois Township.

EACH year sees more Sauerman Drag-Line Cableway Excavators installed than any preceding year, and 1919 broke all records in this respect.

If you are not already acquainted with the reason for the steady increase in the use of these drag-line excavators for excavating sand and gravel and handling loose materials, just ask yourself this question: "What is more economical than an excavator that not only digs, but also elevates and conveys material any distance up to 700 feet and dumps at any desired point?"

There you have the answer. It is the ability of the dragline cableway excavator to dig over long spans and to depths beyond the reach of a steam-shovel or a boom dragline excavator, and particularly its economy and efficiency in handling materials from under water that have influenced so many sand and gravel operators to give preference to this type of equipment.

A Sauerman Dragline Cableway Excavator is economical to operate. One man at the levers of a two-drum hoist controls all the operations of digging, conveying, elevating and dumping. After dumping, the bucket returns to the digging point by gravity.

The experience of the Sauerman organization of engineers is at your service if you have a gravel deposit to develop, levees to build, pond or river to clean out, overburden to remove or any similar work involving excavating and moving of loose materials.

If you have never had a copy of our 130-page illustrated catalog, write for one today.

SAUERMAN BROS.

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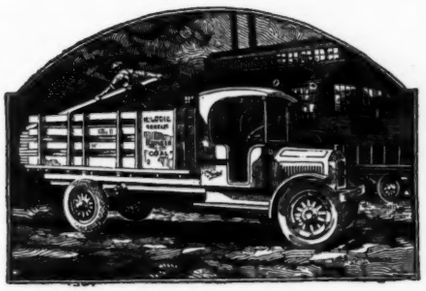
GARFORD



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So it has been the aim of the five factories of this great company to produce machines and equipment with certain essential qualities:

Design, advanced—first proven practical in actual service.

Material, sturdy and lasting—always a little better than the service calls for.

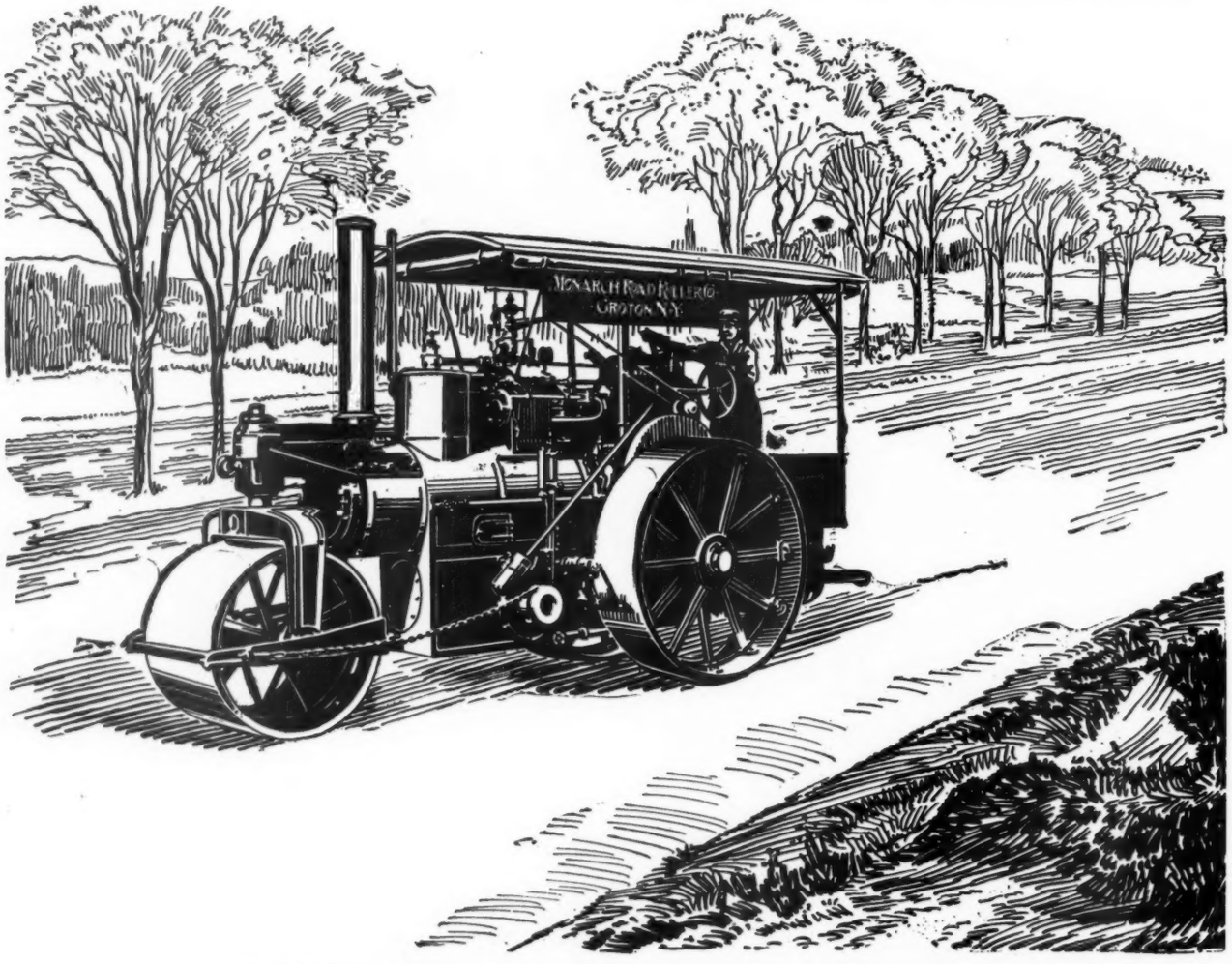
Workmanship, without question the finest to be had—to accord strictly with the G. R. M. Co. standard.

Type, that demanded by its users and the working conditions to be met—"tools to fit the job".

Surely and well this work has gone on. Until—Today, the GOOD ROADS Machinery Company offers a product for every street and road building use. So, we add—

Service, "Everything for the Road Maker".

This means that you can get your road grader, roller, rock crusher, oil distributor, culvert pipe, heating kettle, road drag and so on, *all* from one source.



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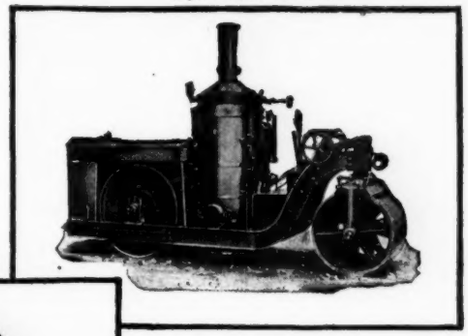
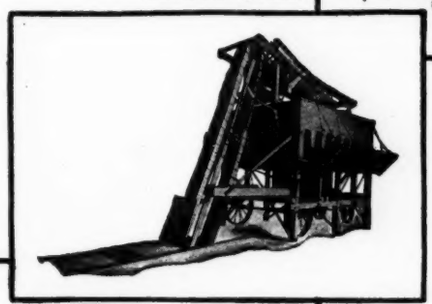
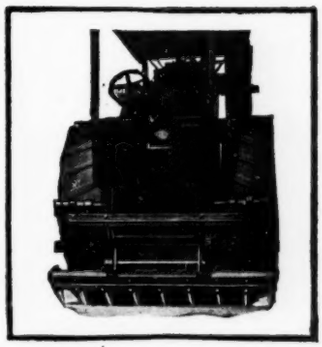
Monarch Tandem Road Roller made in 5-, 6-, 9- and 10-ton sizes.



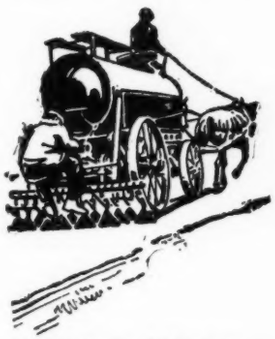
The Winner Portable Gravel Screening Plant.



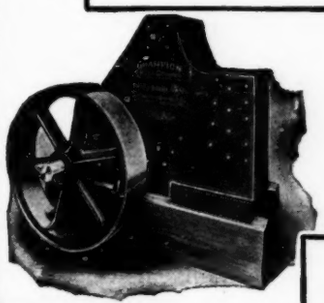


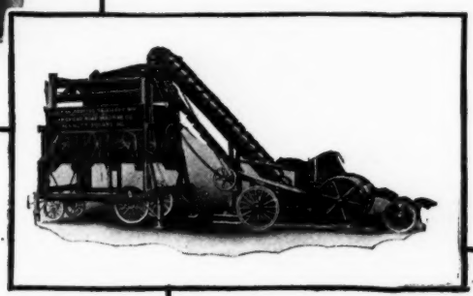
No. 4½, 10 x 20, Champion Steel Rock Crusher on sills.

Monarch Roller with Scarifier Attached.

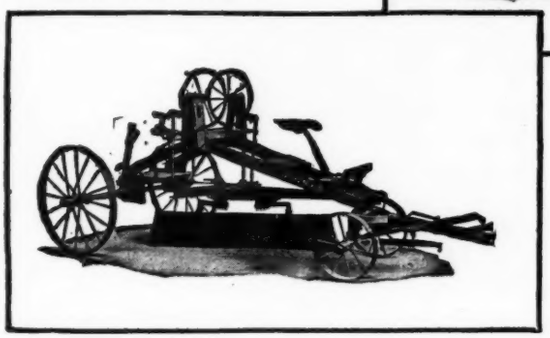


Monarch Pressure Oil Distributor.

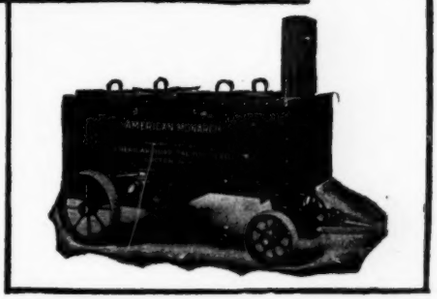




Champion Portable Crushing Outfit, consisting of a crusher, mounting elevator, screen and portable stone bin.



The Little Winner Steel Reversible Road Grader.



Monarch four-wheeled Heating Kettle.

(Concluded from Page 34)

machine is of all-steel construction and of light weight. It is operated by one man.

The design of the boom and skimmer bucket permits straight crowding or skimming to a length of about 14 ft.

AUSTIN COMBINATION DRAGLINE MACHINE EQUIPPED WITH 30-FT. BOOM, CRANE AND HOOK.

This far exceeds the capacity of the ordinary steam shovel of like yardage for road grading and construction. As a shovel, the machine is fast and powerful. It revolves in complete circles and excavates and dumps in any direction.

Equipped as a crane, it possesses speed, economy, durability and portability. As a clamshell excavator it meets

AUSTIN COMBINATION DRAGLINE MACHINE HANDLING ONE-HALF YARD CLAMSHELL BUCKET.

the requirements of a fast, portable and efficient excavator of the clamshell or orange peel bucket type.

The accompanying views show the machine with combination boom and skimmer, with power shovel attachment, with a 30 ft. boom crane and hook, and with a clamshell bucket. These views give an idea of the range of work possible with this machine which is manufactured and marketed by the F. C. Austin Company, Inc., Chicago.

DESIRABLE FEATURES IN JOINTED BLADE ROAD MAINTAINERS

There are several kinds of jointed blade road maintainers on the market. Any type possessing the following features is recommended by the Department of Public Works of the State of Nebraska:

1. The wheel base should not be less than 13 ft. and the frame well stiffened.

2. The blade should be hung midway between the front and rear axle.

3. The blade should be equipped with a locking device so that when the blade is once adjusted it can be kept in position.

4. The maintainer should be equipped with a device, so that all of the segments can be lifted at once.

5. The mould board should be so designed that the dirt will roll along in front of the board and not deposit at the sides.

6. The rear wheel should be set in from the end of the blade so that fills can be dressed to the shoulder line with out having the wheel break down the fills. The rear wheel should also clear any bumps that spill from the end of the blade.

The patrolman operating a jointed blade maintainer should always have his blades sharp. He should provide himself with an extra set, so that his machine will not be laid up when it becomes necessary to sharpen the blades.

The machine should be well greased. This means that all working parts must be thoroughly lubricated including the chains of the raising and lowering devices.

In operating a maintainer it should be thoroughly understood that the machine is designed for maintenance alone, and not for grading the road.

The blade should always be set level with the bottom of the front and back wheels.

In making the first round the outer blade should be in the ditch at a slope corresponding to the finished cross-section of the road. The remaining blades should be set to conform to the finished surface.

The inside slopes of the ditches must be kept free from weeds; unless this is done the maintainer can not be worked successfully. This slope is the source of supply of clear dirt for building up the shoulder of the road; also all of the dirt that is washed into the ditches by rain is brought to the road over the inside slope of the ditch.

The best time to use the maintainer is when the earth contains moisture enough to work well and not stick on the blade.

The best speed to operate the maintainer is from 4 to 5 miles per hour.

The object of the maintainer is to cut off bumps and fill depressions. For a while the operator will be called upon to use some skill in accomplishing this, but after a while he will have the road in such shape that the amount of dirt carried in front of his mould board will be uniform. The road then will be in perfect shape, and practically no adjustment of the blades will be required by the operator.

A truck or tractor is the best power for a maintainer.

A complete outfit with motor power and maintainer requires two men, one driver and one operator.

NEW MACADAM ROLLER DESIGN

Since the invention and perfection of the macadam road roller some thirty or more years ago, there has been practically no change in design. After many years of experimental work and tests under actual working conditions, the Iroquois Department of The Barber Asphalt Paving Company has perfected and

(Continued on Page 40)

Your Success Depends on Quality Equipment

YOU are selling square yards of concrete. Maximum dollars will be to your credit in the bank this year if you do two things —use a Smith Simplex Paving Mixer and organize your loading schedule to keep up with Smith Simplex speed.

You can't crowd a Smith Simplex. It is faster than the fastest loading scheme. And it's a steady, dependable machine—surprisingly simple, adaptable to every requirement of road construction, economical in operation, sturdy and powerful.

Don't experiment this year. Buy a Smith Simplex.

Investigate the advantages of the Band Friction Hoist, interchangeable Boom and Bucket or Swivel Chute delivery, interchangeable caterpillar or wheel traction, highest drum built, central drum ring, worm gear automobile type steering mechanism, actual one-man control—as found only in this Paver!

Three Sizes—10E, 14E and 21E

"101 Reasons" is an interesting booklet—Write for it

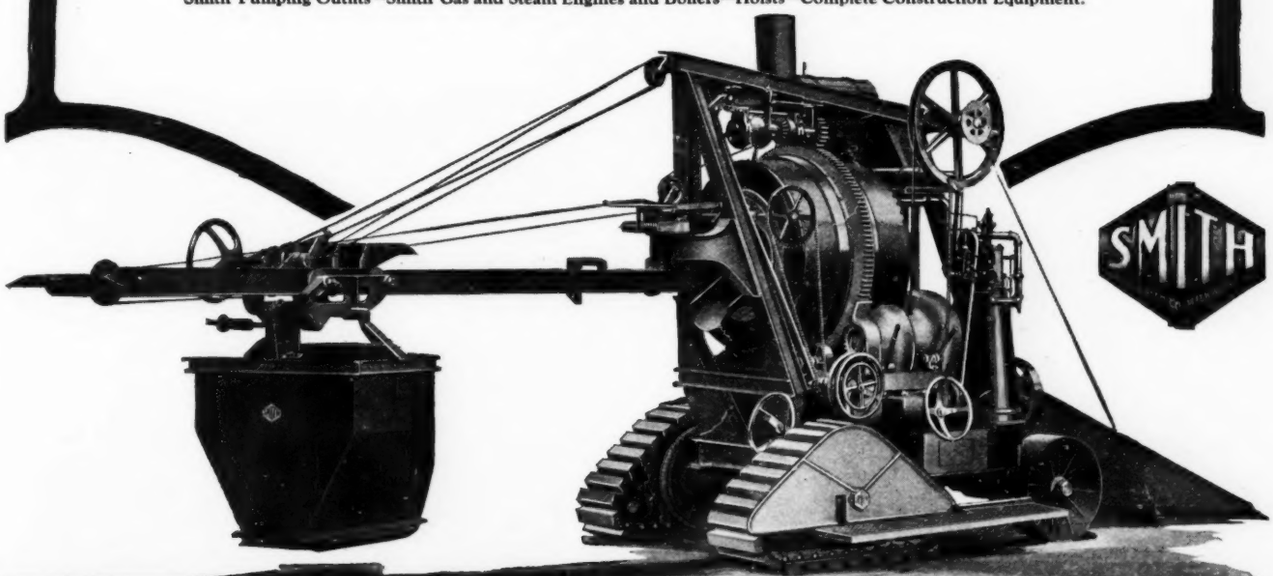
THE T. L. SMITH COMPANY

471 OLD COLONY BUILDING

CHICAGO ILLINOIS

Factories at Milwaukee, Wisconsin

Smith Tilting Mixers—Smith Non-Tilting Mixers—Smith Simplex Paving Mixers—Smith Excavator and Loader—Smith Pumping Outfits—Smith Gas and Steam Engines and Boilers—Hoists—Complete Construction Equipment.

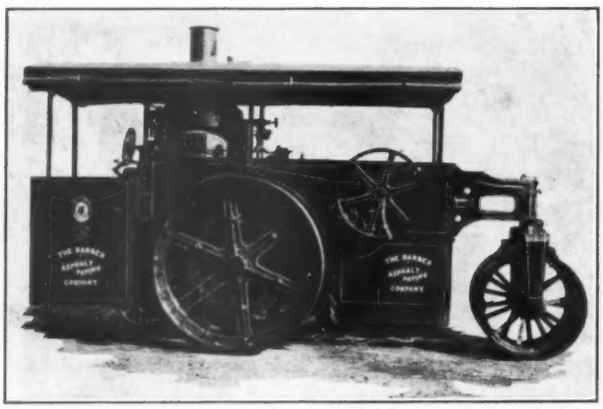


SMITH PAVER

(Concluded from Page 38)

placed on the market an entirely new type of macadam road roller.

The most noticeable feature of the new Iroquois Roller is the vertical boiler which rests upon the steel framework of the roller itself, a separate unit to which nothing is bolted, thus relieving the boiler from any of the wracking strains and weights imposed upon the horizontal boiler of the old type macadam roller. The boiler of the new Iroquois macadam roller may be easily removed for repairs without disturbing any other part of the roller. It has over 50 per cent. more heating surface than in the old type roller.



SIDE VIEW OF NEW IROQUOIS MACADAM ROAD ROLLER SHOWING BELT WHEEL FOR OPERATING STONE CRUSHER OR OTHER EQUIPMENT.

Extreme accessibility and simplicity is the keynote of design and every part is so placed that it is "get-at-able" and ruggedly constructed of the best material to perform the work required efficiently and economically.

The engine is also a separate unit and rests upon the roller framework, on a three point suspension that has demonstrated its many advantages in automobile construction.

The drive is accomplished through a differential gear to the rear wheels. This may be locked out for hard straight pulls. Positive steer is assured through a steel quadrant that prohibits the front roll dragging and shoving up the surface of the highway. The rear wheels are equipped with demountable rims, easily renewed when worn.

A steam scarifier is part of the standard equipment. It is adjustable, scarifying any depth desired the full width of the roller, in the hardest kind of material; a performance which has never been equalled by any other roller.

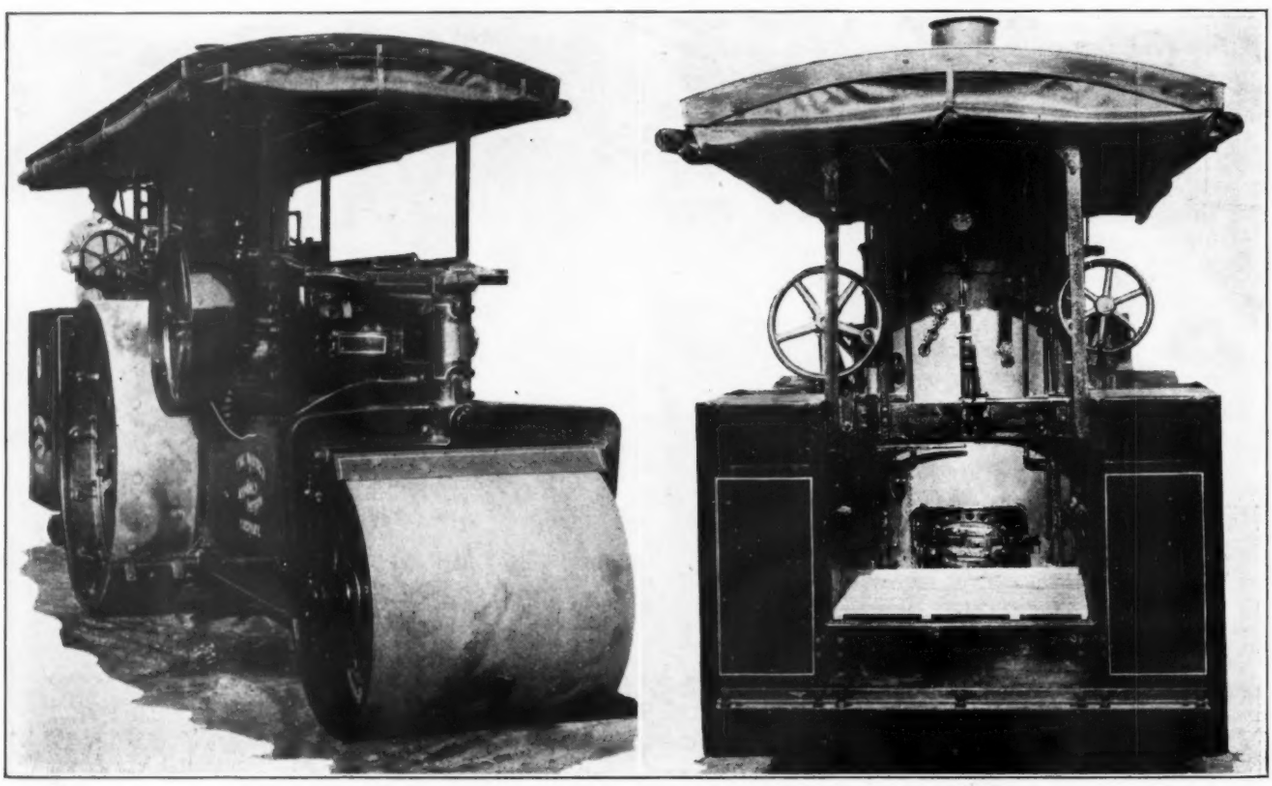
Shifting of gears is entirely eliminated and speed changes are made unnecessary, as the engine is much more powerful than in the old type roller, due to higher steam pressure and larger engine cylinders. It has all the flexibility in operation of a tandem roller.

Despite the high appearance of the roller, the center of gravity is in reality lower than on the old type, absolutely prohibiting any danger of tipping over. The boiler is equipped with a feed water heater to insure economy in operation.

MODERN USES OF TRENCH EXCAVATORS

By J. McElroy, Sales Engineer, Pawling and Harnischfeger Co., Milwaukee, Wis.

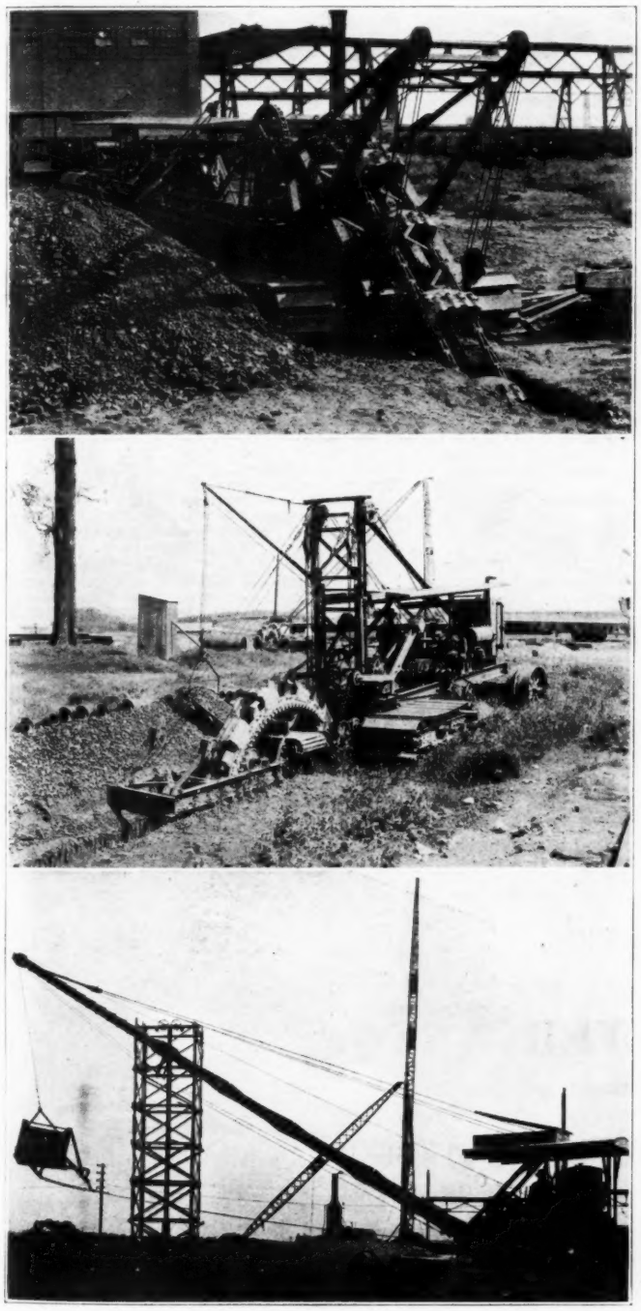
The use of a trench excavator, some years ago, was considered somewhat foolhardy. Contractors felt that



VIEWS OF NEW, VERTICAL BOILER, IROQUOIS MACADAM ROAD ROLLER.

BARE COST OF OPERATING TRENCH MACHINES, NOT INCLUDING PIPE GANG

Maximum Capacity	Fuel Used in Gallons in Ten Hours	Hard Grease and Waste	Lubricating Oil	6% for Full Year 10% for Season Int. on Investment Daily Rate	Life of Machine 10 Years Depreciation per Day	Estimated Cost of Repairs, 200 Working Days	Salary of Operator and One Helper	Estimated Capacity Lineal Feet in Ten Hours	Average Delays in One Season	Cost per Lineal Ft.	Cost per Cu. Yd.
4½ ft. x 23 in.	20	$0.20	$0.40	$2.00 per day	$2.50 day	$2.00 day	$12.00	2,500	20%	$0.012	$0.06
4½ ft. x 24 in.	25	.20	.40	2.25 per day	2.75 day	2.25 day	12.00	2,250	20%	.014	.035
5½ ft. x 18 in.	25	.20	.40	2.25 per day	3.00 day	2.25 day	12.00	2,250	20%	.015	.05
6½ ft. x 24 in.	35	.20	.60	2.50 per day	4.00 day	3.00 day	12.00	2,000	20%	.02	.04
7½ ft. x 28 in.	35	.20	.60	3.00 per day	4.00 day	3.50 day	12.00	1,500	20%	.026	.042
12 ft. x 31 in.	30	.20	.40	3.00 per day	4.00 day	2.50 day	12.00	1,000	20%	.037	.032
15 ft. x 42 in.	35	.20	.60	3.00 per day	4.00 day	3.00 day	12.00	600	30%	.08	.04
18 in. x 42 in.	40	.20	.90	4.00 per day	5.00 day	4.00 day	12.00	500	40%	.12	.05
Backfiller	8	.10	.20	1.00 per day	1.50 day	.50 day	6.00	800 to 1,000 cu. yds.	10%	....	.015



LADDER AND WHEEL TYPE EXCAVATORS AND BACKFILLER, OF PAWLING & HARNISCHFEGER MAKE, SHOWN IN OPERATION.

they would rather use hand labor on which they could figure a positive daily yardage or nearly so, than to gamble on a heavy, cumbersome machine which might run for an hour and then stop for a week. At the present time heavier trenching machines have reached a high state of efficiency which makes them almost indispensable to the ditching contractor, not alone on account of their increased productivity but also because the hand laborer, or old time "navvy," is fast becoming an extinct species.

Trench machines were first used on deep sewer work alone. Now, however, we find them used on sewer, water, gas, telephone conduits, farm tile, and oil pipe lines and even excavation for curb and gutter. The use of trench excavators is no longer in the realm of experiment and the matter of trench excavating has narrowed down to a selection of the model and type of machine best suited to the work in hand. On sewer work the best type is the ladder or boom type. This style has a longer range of depth than the wheel type machine. Another feature of the ladder type machine is its flexibility. It can be readily extended to dig to greater depth by applying an extension to the ladder, always providing of course that the component parts of engine and frame will carry the added weight of the ladder extension.

On gas, water, conduit, farm tile, and curb and gutter excavation the wheel type machine is preferable. For any work less than 8 ft. deep the wheel type machine is the better. The mounting of scoops or buckets on the periphery of a wheel, which in turn is hung on a frame suspended by cables at front and back, gives a circular digging action. More buckets are thus engaged in the actual digging at one time than is possible with the ladder type which digs in a straight line. After many tests it has been found that the wheel type machine will dig more frozen ground and hard material than the ladder; in fact, it will dig to the same depth faster, both machines having equal power. This result is apparent because of the more rigid digging action of the wheel type machine.

On the other hand the ladder type machine has the advantage of being able to dig backwards or to tunnel under obstructions, such as gas and water pipes. The mounting of the buckets on the ladder gives greater clearance for the excavated material. It is possible, to overload the buckets and to drag boulders which are even larger than the buckets themselves, these boulders being finally pushed up on to the conveyor. Such performance is not possible on the wheel type machine owing to the limited space between bucket and wheel.

Machine operators can make a success or failure of a

trench machine, so it is important that a man be properly trained for this work. It is usual and sensible to have a backfiller following the trench machine after the pipe is laid. A very successful form of backfiller is the miniature dragline mounted on caterpillars with a boom and self-filling scraper. This machine requires but one man to operate. The two types of trench excavators and the backfiller are illustrated herewith.

The accompanying table gives approximate costs of operation of trench machines of both types and also a backfiller. This data can be considered only as an average, as capacities are always subject to local conditions.

Contracts Awarded

ROADS AND STREETS

Ala., Selma—Alabama Paving Co., Birmingham, awarded contract for paving Selma Ave., at approx. $65,000.

Ariz., Yuma—L. M. White and C. M. Miller, Yuma, awarded contract for paving Second Ave.,—1st to 8th Sts.,—approx. 5,000 ft., at $76,161.

Ark., Arkansas City—Desha County Road Impvt. Dist., No. 2, awarded contracts to following for construction of 110 mile road, Warrenite on concrete base and gravel; brdgs., etc.: Sects. 1, 2 and 3 and 5 to Warren Bros., Boston, Mass., Sects. 4 & 6 for gravel surfacing, to $459,784 to Perdue & Hill, Pine Bluff, Ark.; grading, grubbing and clearing at $500,000 to Arpin Bros., Wisconsin. Cost of Warren Bros., contract. $2,717,500.

Ark., Jonesboro—Roach & Shuford, Memphis, Tenn., awarded contract to construct 16.25 miles of road; gravel; $150,000.

Cal., Bakersfield—Rogers Bros. Co., Los Angeles, awarded contr., for paving with concrete the Fellows-McKittrick road, at $369,000.

Cal., Dixon—Ransom-Randle Co., Sacramento, awarded contract for improvement of 23 blocks Warrenite pavement, concrete and cement gutters, etc., at $151,508.

Calif., Gridley—Clark & Henery, awarded contract for paving 30 blks. of streets here, at $165,286.

Cal., Los Angeles—Geo. R. Curtis, 2440 E. 26th St., awarded contract for paving Temple St.,—Vermont Ave. to Wilton Place—also sewers, and sanitary, at $139,910.

Cal., Los Angeles—D. L. Gaskill, 236 Hermosa Ave., Long Beach, awarded contract for grading roadways and constructing curbs and walks in 8.5 miles of streets in Graham, known as Rd. Dist. Impvt. No. 151 at $114,730.

Cal., Los Angeles—T. E. Hill & Co., 1011 Washington St., City, award. contract for improving approx. 8 miles of Santa Paula-Ojai Road, of which 4 miles is to be paved with concrete. at $115,494.

Cal., Los Angeles—Geo. R. Curtis, City, awarded contract for street and sewer impvts. on Temple Street—Vermont Ave. to Wilton Pl.—at $139,910. Job involves 341,023 sq. ft. paving (asph.), grading, curbing and large conc. storm drain in Temple St.

Cal., Fresno—Thompson Bros., Fresno, awarded contract for paving 5.35 miles county highway on Blackstone Ave., at $96,078; also contract for paving 11.99 miles on Elm Ave., with black base and Warrenite top, at $228,660.

Cal., Fresno—Hugh Crummey, San Francisco, awarded contract for paving 6.01 miles on Sect. A, Route 33, County Hwy. with 5-in. asphaltic concrete, Warrenite type, at $139,455.

Conn., Hamden,—Sperry Engineering Co., 82 Church St., New Haven, awarded contract for paving 2½ miles of highway (concrete) at about $100,000.

Cal., San Diego—**David H. Ryan, local,** awarded contract for paving 5 streets in Brawley, at $128,000.

Ga., Columbus—Cooper Campbell, awarded contr. for constructing paving on Second Ave.,—17th street to 30th; 6th Ave.,—14th to 15th; on 15th st.,—Broad to Second—at total cost of $200,000.

Ga., Macon—W. Z. Williams Constr. Co., awarded contract by Bibb County Commrs., for constructing 6 2-3 miles Dixie Hwy.,—Macon to Jacksonville (69.844 sq. yds. conc. paving) at $232,225.

Ga., Sylvester—Speed Parkers, Inc., Louisville, Ky. awarded contract for paving approx. 3½ miles of rd. on Sylvester and Albany Road. Est. cost $100,000.

Ind., Anderson—Madison Constr. Co., Anderson, awarded contract for impvt. of Carrol Road—abt. 3 miles no. of Alexandria, at $92,600.

Ind., Delphi—J. C. O'Connor & Sons, City, awarded contracts for construction of concrete roads, in Wabash Co. (2) at $151,780.

Ia., Reinbeck—Bryant Asphalt Paving Co., 807 Black Bldg., Waterloo Ia., awarded contract for street impvts. consisting of following: 35,000 sq. yds. Bitulithic, as $104,000.

Ky., Harrodsburg—Lutes & Co., Lexington, Ky. awarded contract to construct 7 miles of road—Shakertown to Harrodsburg—at $88,000.

La., Franklinton—G. W. Prutzman & Bonnerdell & Lang, awarded contracts by Washington Parish Police Jury, for constructing 23 mi. Franklinton—Pearl River Hwy.; Sects. A-1 and A-2; gravel; 11.97 mi. Franklinton—Mississippi State Line Hwy.; gravel, $408,000.

La., Monroe—Porter & Boyd, Charlotte, N. C., awarded contract to construct Jackson Hwy.—Monroe to connect with Charlotte Savannah Hwy. at $500,000.

Mass., Cummington—M. L. Camarco, Lee, awarded contract for road, at $192,464.

Mass., Quincy—Coleman Bros. Marginal Street, Chelsea, awarded contr. for paving Furnace Brook Parkway, at $150,000.

Mich., Gaylord—Midland Constr. Co. Midland, awarded contract for grading, draining and surfacing 6.169 miles of State Trunk Line Road, at $131,414.

Mich., Lansing—Beaverton Constr. Co., Beaverton, awarded contract for Rd. 30-3, Gladwin Co., 6.443 mi., at $98,360. Gohr Bros., Lansing, contract for road no. 265, Clinton Co., 7.411 mi., at $112,435.

Mich., Lansing—Gohr Bros., 1433 Ada Street, Lansing, awarded contr. by State Hwy. Dept. for grading and surfacing 7.411 miles Assessment Dist. Rd. no. 265 at $112,435.

Minn., Duluth—D. H. Clough & Co. awarded contract for 50 blocks of concrete street and walks. Appropriation of $2,000,000 made for this improvement.

Mo., St. Louis—Louis Rich Construction Co., East St. Louis, awarded contract for constr. of series of hard surfaced roads in Arkansas, at $2,000,000. First unit is 72½ miles long and company estimates it will take two years to finish same. It will be of bitum. macadam constr. 63 rein. conc. culverts will have to be built.

Neb., Aurora—C. C. Chapin, San Antonio, Tex., awarded contr. for paving, at $345,000.

Neb., Blair—Western States Co., Omaha, awarded contract for paving 33,935 ft. main streets. 25 ft. wide, involving 78,823 sq. yds. concrete, at $288,043.

N. M., Santa Fe—Michou, Millar Clark, Teyssier, Box 272, Santa Fe, N. M. awarded contract for constructing New Mexico Fed. Aid Prop. no. 1-b, Colfax Co., involving 14.37 miles of road at $149,546.

N. Y., Brooklyn—Brooklyn Alcatraz Asphalt Co., 407 Hamburg Ave., awarded contract for furnishing labor and material for improving East Drive, Prospect Park, at $127,044.

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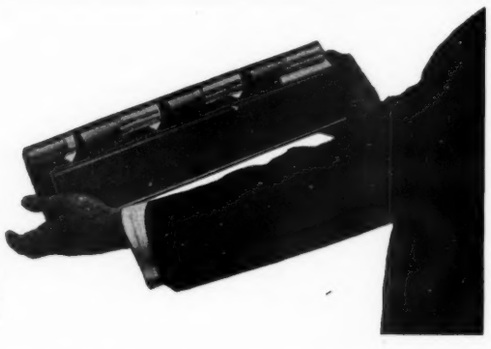

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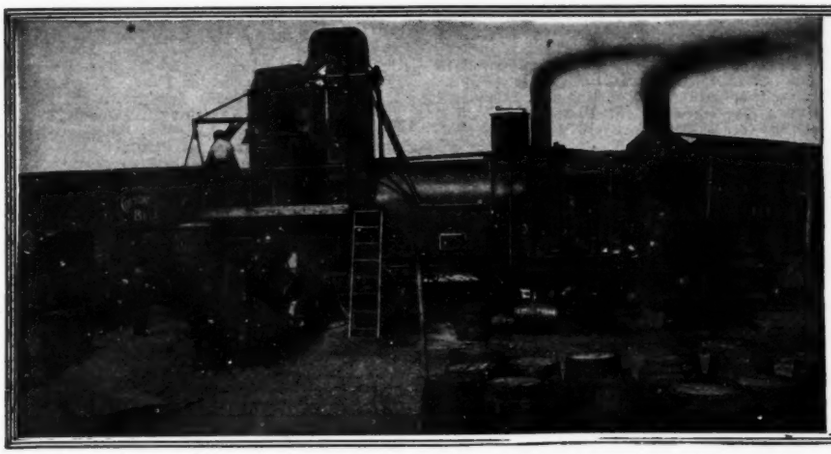

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PHILADELPHIA

N. Y., Bronx, N. Y. City—Uvalde Asphalt Paving Co., no. 1 Broadway, awarded contract for paving Riverside Drive—135th to 147th Sts.—at $108,896. Daveny Asph. Co., Inc., 438 E. 91st St., award. contract for paving between 147th and 158th Sts. on the Drive, at $118,670; Queens Borough Maurice E. Connolly, Pres. let following contracts for paving Broadway and Queens Ave: Consolidated Asphalt Paving Co., 52 9th St., Brooklyn, $35,891 and $170,316, respectively; Corona, Cooper & Jackson Aves., to Uvalde Asph. Paving Co., 1 Broadway, N. Y. City, at $24,375, $11,548 and $32,980, respectively; Rockaway Plank Rd., to Union Paving Co., Broadway & 112th St., New York City at $172,497.

N.D., Jamestown—F. Burke & Sons, Fargo, awarded contract by City for hard-surfacing streets in business section, at about $270,000.

Okla., Broken Arrow—J. H. Hamilton, Bartlesville, awarded contract for paving 5 blocks main streets, 25 ft. wide, 1 course conc., at about $40,000.

Ore., Seaside—The J. H. Tillman Co., awarded contracts for impvts. of rds. at Gearhart and Seaside, at approx. $120,281.

Pa., Erie—Charles Fry Constr. Co., awarded contract to construct 2 mi. paving of Grub Road, Millcreek Twp., at $70,527.

Pa., Harrisburg—Leo E. Kelly, 296 Stuyvesant Ave. Brooklyn, N. Y., awarded contract for bldg. 5325 ft. vitr. brick roadway in State College Boro., at $154,878.

Pa., Harrisburg—Weller Constr. Co., Washington, awarded contract for constr. of 29,100 ft. state road betw. Yellow House and road to Pottstown, at $221,128.

Pa., Harrisburg—R. B. Markley, Rochester, Pa. awarded contr. for bldg. section of State-aid Highway—approx. 13,592 ft. long—in Daugherty and New Sewickley Twps., Beaver Co., at $150,770; Smith-McCormick Co. and McInerney & McNeal, Inc., Easton, Pa. awarded contract for bldg. 15,000 ft. rein. conc. rdway. extending from no. west line of Easton to the Tatamy Boro. line, at $165,526.

Pa., Harrisburg—Warren Brothers Co., Boston, awarded contract for 37,688 ft. concrete construction on state highway—Janette to New Kensington, at $668.000, approximately; Fish, Rutherford, Inc., Phila. contract for work in Montgomery county near Hatfield, at $73,007. Total aggregate cost of contracts, awarded State Hwy. Comn. on which work will start as soon as weather permits, is $1,000,000.

Pa., Pittsburgh—Jno. W. Butler Co., awarded contract for constr. of Rock Run Rd.,—Buena Vista to Boston Extension Rd., Elizabeth Twp.—$124,814. Road will be of rein. conc. and be 2 miles long, 16 ft. wide.

Tex., El Paso—El Paso Bitulithic Co., awarded contract by El Paso County Commrs. for Constructing 4 miles on Island Road; bitum. surf. on conc. base; $120,000 available.

Tex., Lubbock—Panhandle Construction Co., Plainview, awarded contract by City Comn. for 75,000 sq. yds. vertical fire brick paving, at $295,000.

Tex., Nacogdoches—County bid to do its own construction work, awarding contract to R. E. Barham, County Engineer, on bas's of 4¾% total work amounting to $1,000,000.

Tex., San Angelo—C. B. Metcalfe, San Angelo, awarded contract for water bound macadam road at $167,908; J. E. Ward, Dallas, awarded contract for asph. surface at $28,426.

Tex., Tyler—Smith County let contr. for bldg. Porters Bluff Rd., from here to Van Zandt Co., (3.94 miles conc. and 4.78 mi. of gravel) to Harris & Powell, Tyler, at $100,065, at $177,670.

Va., Charlottesville—Ganaway & Hudgins Co., Portsmouth, Va., awarded contract by Va. State Hwy. Comn., to construct 7.3 miles bitum. macadam (penetration) road 16 ft. wide, betw. Mechum's River and Seven Oaks, Albemarle County, Va. Proj. no. 43, at $202,000.

Wash., Spokane—Mitchell Brothers, local, awarded contract for grading 28 miles of road betw. Connell and Lind, at $88,606; Fitzgerald & Staunton, Great Falls, Mont., awarded contract for grading 9 miles betw. Delaney and Dodge, at $76,151.

Wash., Tacoma—Grant-Smith Co., Seattle, awarded contract for constructing Road Carbonado to Fairfax—at $223,750.

W. Va., Fayetteville—Johnson & Dougher. awarded contract to pave 7.75 mi. rd., Nuttall Dist., at $107,130.

SEWERAGE AND SEWAGE TREATMENT.

Ark., Arkansas City—James Stanton, Jr., Seneca, Kansas awarded contr. for building sewer here, at $192,000.

Ariz., Yuma—Geo. S. Benson & Sons, Stimson Bldg., Los Angeles, award. contract to construct sewer system comprising about 13 miles of pipe, including 6 miles of 20-in. outfall sewer and sewage pumping plant at about $91,000.

Cal., Los Angeles—Chas. T. Salata, awarded contract for constructing clay pipe sewer in 37th St., (San Pedro) betw. Pacific Ave. and Carolina St., at $1,980.

Cal., Los Angeles—Adam Dalmatin, award. contr. for constructing clay pipe sewer in Occidental Blvd.—Belleue Ave. to Marathon St., at $14,886; B. D. Zaich, award. contr. for constructing clay pipe sewer in Lyman Pl., at $4,490.

Cal., Los Angeles—S. Zarubica, 3006 Sixth Ave., awarded contract for constructing clay pipe sewer in Morton Ave.,—Country Club Drive to 8th Street, at $6,278; Mike Chutuk, 1506 Pleasant Ave., awarded contr. for constructing clay pipe sewer in 62nd St.,—Figueroa to Moneta Ave., at $1,969.

Cal., San Bernardino—F. W. Seccombe, awarded contract for constructing vitr. pipe sewer in 13th St., at 43 cts. ft. for 4-in. and 63 cts. ft. for 8-in. sewer and $85 each for flush tanks.

Cal., San Bernardino—W. D. Bohn, awarded contract for constructing sewer in Arrowhead Ave.,—Highland Ave. to no. city limits—at $2,361.

Colo., Denver—Redwood Mfg. Co., 822 East Third St., Los Angeles, awarded contract for supplying and installing 8-in. vitr. pipe in Sub-District 18, West and South Side Sewer, to wood stave pipe from chlorination tunnel to surg. chamber site at so. portal of Mission Tunnel, at $10,772.

Conn., Derby—J. Driscoll, Brightwood Ave., Torrington, awarded contr. for laying sewers in various streets, at $28,460.

Conn., Windsor—F. A. Barone, 16 Windhester St., Hartford, awarded contract for constr. of new sewer here.

D C., Washington—Contracts for construction of service sewers in the Dist. of Columbia, involving constr. of approx. 2,800 linr. ft. pipe sewers, awarded as follows:

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Warren F. Brenizer Co., 101 New York Ave., N. E. Washington; $3,543 and $5,801, respectively; Geo. Hyman, 1101 Morse St., N. E., Washington, contr. for sewer "E," at $4,202.

Fla., Ft. Myers—W. R. Wallace & Co., awarded contract by City for constructing sanitary and storm sewerage system, at about $30,000.

Fla., Palmetto—Tinkham & Skeen, awarded contract by City for constr. of sewer system, at $4,000.

Ida., Idaho Falls—Lindstrom & Oren, Butte, Mont., awarded contract by City for laying 28,000 ft. 8-18 in. vitr. sewer pipe, at $72,761.

Ill., Carlinville—Boatman & Hays, awarded contract for constructing sewers on the Arnett and Murphy additions.

Ill., Nokomis—W. T. Foley, Chicago, awarded contract for constr. of sewer district no. 1.

Ind., Ft. Wayne—Fred H. Fuelling & Son, 1324 Eliza Street, Fort Wayne, Ind., awarded contract for constr. of sewer in and along alley of So. Wayne avenue and in Tacoma Ave., at $3.67 per linr. ft.

Ind., Indianapolis—Sheehan Constr. Co., awarded contracts for constr. of 3 Sewers as follows: in portion of Meridian St., at $843.15; portion of Holmes Ave., at $2,592, and in portion of Barth Ave., at $1,099.

Iowa, Boyden—City let contracts for laying 19,000 ft. 28-in. sewer pipe and 3,200 ft. 4-in. water pipe to Dearborn Constr. Co., Waterloo Savings Bldg., Waterloo, at $35,079 and $3,921 respectively; sewage disposal plant to Ward & Weighton, 516-17 Davison Bldg. Sioux City, at $12,200.

Ia., Chariton—P. E. Johnson, local awarded contract for sewers on Middle Road and Fernwood Ave., at $1,209.

Ia., Clinton—Thos. Carey & Son, awarded contract for constructing sewer on 15th Ave.,—3rd to 4th Streets—at $1,690.

Mass., Boston—Wm. Barrett & Co., award. contr. for sewerage works in Oswego Street—Albany street to Harrison Ave., at $10,622.

Mass., Boston—J. Guarino & Co., awarded contract for sewerage works in Wade St.,—Commonwealth Ave. to 650 ft. southwest, Brighton, at $8,267; Anthony Cefalo, contr. for sewerage wks. in Malcom Street—N. Y. N. Haven & Hartford R. R., to Belgrade Ave., West Roxbury, at $1,176. Commr. of Pub. Wks. granted permission by Mayor to construct, with the Dept. Force sanitary sewer of 12-in. earthen pipe in Snow Hill street—Sheafe St. to Hull St., city proper. Est. cost of labor and materials, $1,650.

Mass., Boston—Geo. J. Reagan, awarded contract for sewer work in Wilbur Street, Dorchester, at $1,863.

Minn., Duluth—Nester Johnson, awarded contracts for sanitary sewers in Grand Ave.,—Polk Street to 66th Ave., W,—at $3,497.

Minn., Duluth—Olson & Johnson awarded contract for sanitary sewer in 40th Ave., W. from Grand Ave. to Rene alley, at $4,-965.

Minn., St. Paul—De Graff Wolff, awarded contract for constr. of the Somerville sewer at cost of $39,960.

Minn., St. Paul—Feyen Constr. Co., 277 Burgess St., awarded contract for installing house sewer connections on Grand Ave., at $1,999 and on Charlton, at $522; Morris, Shepard & Dougherty, Geo. J. Grant Constr. Co., 310 Waucouta St., awarded contract for constructing sewer at $67,280; Thornton Bros., 304 Am. Bk. Bldg., contr. for constructing sewer at $15,456.

Mich., Grosse Pointe (Detroit, P. O.)—G. R. Cooke, 1260 Penobscot Bldg., Detroit, awarded contract for bldg. storm sewers in Jefferson Ave., with outlet into Lake St. Clair, involving 1100 ft. 36-in. rein. conc. and 2,490 ft. 15-24 in. vitr. pipe, at about $28,000. Work will be done under supervision of M. L. Brown & Son, 823 Chamber of Commerce Bldg., Engineers.

Mich., Muskegon—G. Pontroelli, Chicago, awarded contr. by City for furnishing labor and material for laying 1030 ft. 12-48 in. rein. conc. or segmental blk. sewer in Western Ave. Special Sewer Dist. 30, at $78,514; driving 100 piles in lake, furnishing and placing 980 ft. 48-in. steel pipe with flanged joints, etc. in Sect. 2m Western Ave. Sewer outlet, to N. P. Nelson, Muskegon, at $14,120.

Neb., Omaha—Following contracts let for sewers: J. S. Harrington, 300 Mason, $651, for Sewer Dist. 629; Katz Constr. Co., 409 Brandeis Theatre Bldg. Omaha, $2,637, for Sewer Dist. no. 663; H. J. Peterson, 3701 S. 17th St., at $2,647, for Sewer Dist. 667; J. S. Harrington, 3002 Mason, $651; Sewer Dist. Nos., 664 and at $494 Dist. No. 668; J. J. Haughen, 623 S. 14th St., $12,447, Sewer Dist. 670.

Neb., Scottsbluff—J. S. Swartz, awarded contract for sewers in Dist. 17, at $2,440; Dist. No. 18 at $938; Dist. No. 19, $850.

Neb., Wymore—Arthur H. Dobson, 800 1st Nat'l Bank Bldg., Lincoln, Neb., awarded contract for sewers, at $63,759.

N. J., Newark—Foundation Company, 233 Broadway, New York City, awarded contract by Passaic Valley Sewerage Commrs., for bldg. tunnel under Bayonne and New York Bay, at cost plus percentage basis.

N. J., Passaic—N. A. Pietroniro, 25 Hemlocke St., Paterson, N. J., awarded contract for constructing sanitary sewer in Lexington Ave., at $1,708; also sewer in Albion St. and in Randolph St., at $12,862.

N. Y., Brooklyn—E. Riegelmann, Boro. Pres., let contract for bldg. sewers in Malta Street, to Murphy Bros., 8856 26th Ave., at $7,858; Stillwell Ave., to J. Jennings, $4,706; Kenmore Pl. and Mansfield Pl. to G. Petracca, 175 Spencer St., at $2,604 and $3,493, respectively.

N. Y., Long Isl. City—M. E. Connolly, Pres. Queens Boro. let contracts to J. H. Johnson Constr. Co. for bldg. sewer in Greenpoint Ave.,—Queens Blvd. to Hancock St., at $7,000, Buell Pl., $7,178; to N. Lascalzo 20th St., at $2,993; to C. Petracca, 175 Spencer St., Brooklyn, Merri St., $5,765; to T. Welsh, Beekman St., $3,853; Oxford St., $2,531; H. J. Mullen Constrg. Co., Inc. Fulton St., Jamacia, $2,500.

N. Y., New York—McLoughlin & Buckley, 337 E. 134th St., award. contr. for laying sewers in W. 238th St., Sedwick and Van Cortland Aves., at $12,282; in E. 174th St. Walton & Mt. Eden Aves., at $3,462; to Di Menna & DeBaso, 270 E. 149th St., Britton St. Broon Park and White Plains Roads, at $11,269.

N. C., Wadesboro—Blankenship & McLellan, Charlotte, awarded contr. for constructing sewer lines at $35,000; also water mains, at $5,000.

O., Cleveland Heights—(Warrensville, P. O.) A. Marra, 2276 E. 105th St., Cleveland, awarded contract by Kangesser Realty Co., Park Bldg., Cleveland for bldg. 16,350 ft. 8-24 in. vitr. pipe sewer; 30 brk. manholes; 55 catch basins and 8,210 ft. 4-8 in. c. i. water main, in Taylor Park, at $74,285.

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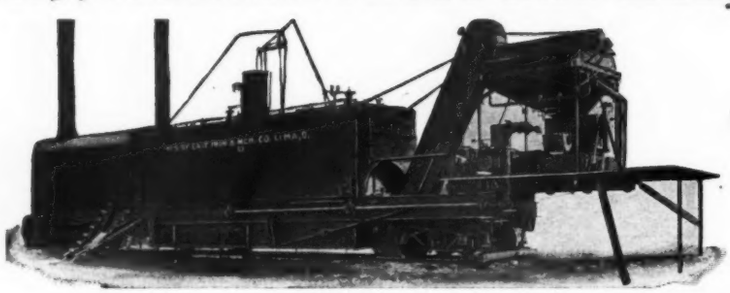

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PROSPECTIVE WORK

ROADS AND STREETS

Ariz., Flagstaff—Road 20 ft. wide, decomposed granite, will be constructed from Flagstaff to top of San Francisco Peaks—about 15 mi.

Cal., Benecia—Col. E. P. O'Hern, Commander of Benecia Arsenal, has announced that $46,000 will be immediately available for constr. of 6 miles of roadways in the Benecia Arsenal grounds.

Cal., Sacramento—$70,000,000 available for highway working in this state during 1920. 11 counties have voted bonds since May in addn. to the good rds. bond issue and $400,000 voted in Modoc county for establishment of engineering grades, brdgs, and culverts. Bond issues voted are as follows: State, $40,000,000; Sonoma County, $1,640,000; Fresno Co., $1,800,000; Napa Co., $500,000; Santa Cruz Co., $24,000; San Luis Obispo Co., $1,500,000; Contra Costa Co., $2,000,000; Yolo County, $810,000; Sutter Co., $810,000; Butte Co., $1,800,000; Imperial Co., $1,000,000 and San Diego Co., $2,300,000.

Cal., San Diego—Prelim. steps to paving one of the largest districts planned in City for some time, are going rapidly forward. New Dist. includes sections of A, Ash, Beech, Cedar, 7th and 8th streets near downtown district.

Cal., San Diego—Bd. of Supvrs. has retained R. M. Morton, Engr. Sacramento, to take charge of bldg. 135 mile highway, almost all of which is 6-in. concrete. $2,300,000 bonds voted for project. J. B. McLees, Clk.

Colo., Colorado Springs—City plans to spend approximately $1,025,000 for various municipal improvements. Chief item will be proposed paving of four principal thoroughfares of city, including N. Cascade Ave., Platte Ave., S. Nevada Ave. and Colorado Ave. Complete estimates of cost of paving will be ready for approval of Council about March 1st.

Colo., Denver—U. S. Govt., State and City of Denver will join in bldg. 5-miles concrete driveway out of Colfax Ave., to U. S. general hosp. No. 21 in Aurora. Work will begin early in Spring and be pushed to completion as fast as possible. Est. cost of project $140,000, Allowance for state's part of expense has been made in 1920 budget of the State Hwy. Comn. Budget, when completed, will provide for expendts. of $2,300,000. Other state projects are: Fall River Rd., $40,000; completion of Big Thompson canon road, $40,000; widening Wolf Crk. pass rd., $25,000; completion of Independence pass rd., $10,000. These will be the only state projs. to be undertaken during year. All other work will be done in conjunction with the Govt.

Colo., Silverton—Board County Commrs. San Miguel Co. passed resolution to pay ¼ of roads and other fed. projects in County. $3,000 appropriated to assist the Forest Service in repairing the road betw. Norwood and Delores, Colo.

Idaho, Boise—County Commrs. have received notification of the placing for immediate use, of $970,000 on Ada County road work.

Idaho, Lewiston—Citizens in Lewiston and Clarkston organizing to promote projected Lewiston-Enterprise Hwy. which is now receiving attention at Wallowa County, Oregon, where a campaign has been start-000 and Asotin Co. $250,000; balance to be borne by state and fed. governments. In this estimate is included a $50,000 bridge over the Grande Ronde River.

Ill., Joliet—City Engineering Dept., plans to improve Joliet system of highways at expendt. of $1,000,000.

Ill., Bloomington—Eng. Packard working on plans for Madison street paving job. Ord. calls for brk. pavement on Madison betw. Grove and Washington Sts., betw. Jefferson & Monroe and on Monroe betw. East st. and Roosevelt Ave. One blk on Market St. will be paved; also on Grove betw. Main and Center. Board ready to ask bids on latter two projects Conc. pavement on Stewart & Wright Sts. in Berenz Addn. will be laid this Spring. City Engr. instructed to prepare plans and est. for pavement on Locust St.,—Main St. to C & A brdg; also on Jefferson betw. East St. and Towanda Ave. This is longest stretch of paving for coming year. It is about three quarters of a mile in length.

Ill., E. St. Louis—Ord. passed providing for repaving of 10th Street Broadway to State. Est. cost $56,600. Plans provide for asph. surface on sides and brick for street car tracks.

Ill., Rock Island—Board of Local Impvts. has approved the following projects: Paving of 40th Street—14th to 18th Avenues, at $17,960; paving of 18th Ave.,—38th to 45th Street—connecting with the 19th Ave. boulevard of Moline.

Ill., Waukegan—Bd. of Local Impvts. adopted Resolution for paving system of streets on North Side—total est. cost to be $79,552.

Ind., Elkhart—City Engr. H. J. Weaver has submitted estimates for paving of 4 streets here as follows: South 6th St.,—St. Joseph St. to Wolf Ave., $40,000; Franklin street—Indiana Ave. to city limits, $35,000; Gladstone Ave.,—Middlebury streets to Goshen Ave., $16,800; Goshen Ave.,—Addition to 160 ft. so. of N. Y. Cent. trks., $12,700. Total est. cost $104,500.

Ind., Gary—City Engr. W. P. Cottingham and Asst. Engr. Bert Canaday, at work on extensive program of public improvements to be made during 1920. Program includes repaving of more than a dozen streets and avenues, including S. Broadway and W. 11th Ave. Est. cost $1,000,000.

Ind., Ft. Wayne—Survey on 3 of the biggest paving jobs now completed. The roads are the Lima, Leo and Decatur Roads and bids will be asked about April 1st. Type of paving to be used on Decatur road not yet decided upon. A. W. Grosvenor, Co. Surv.

Ind., Terre Haute—More than 11 miles of paving is contemplated for 1920. Plans under way in office of City Engr. Koerner, who advocates the use of a 3-in. paving brick for use in the street work.

Ia., Davenport—Paving of 5 main city approaches completely to the city limits, included in 1920 program. Work contemplated for the year including new and repaving work, will aggregate 14.8 miles. Roscoe E. Sawistowsky, City Engr.

Ia., Davenport—Preparations being made by Scott County Engrg. Dept., to call for bids as soon as possible in Spring for paving work. Plans include paving 20 miles of road; also extra grading on as many more mi. for the 1920 paving projects. Plans

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CONTRACTORS' EQUIPMENT OF ALL KINDS

will be ready for inspection of the Govt. about the middle of February, according to Engr. Malloy.

Iowa, Waterloo—Prelim. steps taken by County Bd. to pave 17 mi. of Grant Hwy. thru Blackhawk Co. Est. cost of proj. approx. $750,000.

Ky., Louisa—Lawrence County Commrs. will construct 40 miles of hard-surfaced roads from Va. line to Ohio River, known as Old Dominion Hwy. $250,000 bonds State and Fed. aid, $600,000. Will ask bids in Spring.

La., Lake Charles—Nearly $2,000,000 is available for good road constr. in Calcasieu, Cameron, Allen, Beauregard and Jefferson Davis Parishes. Allen Parish leads in drive for good roads. $525,000 bonds voted to which will be added abt. $250,000 govt. aid. Money will provide for completion of Pelican Hwy. in Parish and a number of east and west roads; Cameron Parish has voted $417,000; Beauregard Parish, with $250,000 bonds voted, will construct hard surfaced rd. connect'g. De Ridder with Lake Charles via Fulton; Calcasieu Parish will build, the Vinton-Orange Rd. which will cost more than $250,000; also 12½ mi. of rd. east of City at cost of $100,000.

Md., Baltimore—First streets to be paved with smooth paving in 1920, making 3 miles in all, have been selected by Paving Comn. and are as follows: Ellwood Ave.,—Eastern Ave. to Boston Street; portions of Lancaster St., Chester St., O'Donnell St., Bolton St., Light St., Russe St. and Barney St.

Mass., Boston—Plans being prepared by City Planning Board, Engrs., City Hall, for widening Exchange Street to 54 ft. Bill presented to State Legislature asking for $1,500,000 for the project.

Mich., Jackson—City will expend $832,-450 for street paving, according to program outlined by A. W. D. Hall, City Engr. For the concrete work 40,000 bbls. cement will be needed.

Minn., Duluth—City Commrs. have ordered London Rd., surfaced from 8th Ave. to 60th Ave., E., with bithu. surf. over Telford base, 18 in. thick. Est. cost $155,190; also 27th Ave., W.—5th to 6th Sts., 6th St.—Lincoln Park to Winnipeg Ave., Winnipeg Ave.,—6th to Devonshire St.—Paved, 24 ft. wide. Est. cost $28,887. J. A. Farrell. Commr.

Minn., Moorhead—Council has adopted resolution ordered paving laid on following streets during 1920: First Ave. N., from 4th to 6th Sts., 5th St., N. from Front St. to 1st Ave.; 6th St. N. to complete blk. betw. Front St. and First Ave. N.; 7th St. N. from Front St., to First Ave. N. R. G. Price, City Clk.

Mont., Anaconda—Deer Lodge and Silver Bow Counties will complete hard surfacing of highway from Butte to Anaconda this Spring; 27 miles. $250,000 available. E. E. Bailey, Deer Lodge Co. Aud.; Sam L. Anderson, Aud. Silver Bow Co.

Neb., Fairbury—Bond election favorable; which means 70 more blocks of paving will be laid.

Neb., Omaha—City Commr. Towl and City Engr. Bruce submitted to City Council list of 60 paving districts ready for advertisement for bids; also another list of 100 districts which have been created and on which proceedings have not passed early stages. Council will select the essential districts for first consideration. Engr. Bruce recommended that Lake Street—30th to 41st—should be paved soon; also 40th—Ames to Grand Aves. and 27th St., Sprague St. to Ames Ave.

N. J., Jersey City—Hudson County Blvd., Commission will repave Hudson Blvd.,—Communipaw Ave. to Central R. R. of New Jersey Bridge. Est. cost abt. $75,000.

N. J., Trenton—Plans for Widening Perry Street approved by City Commr. work will cost about $160,000.

N. M., Santa Fe—Tesuque and Pojuague Road, on Fed. Aid Project No. 14, will be improved at cost of $74,547. A. O. Peabody. Asst. Hwy. Engr.

N. Y., Albany—Following is tentative list of hwys. to be reconstructed and resurfaced in Clinton, Essex and Warren counties during 1920: Clinton, 57; Windoor Pt. 1, 1 mi. bit. mac. reconstruction; 126 Windsor Pt. 2, 1.75 miles bit. mac., resurfacing; 258 Plattsburg-Keeseville; 5.44 miles conc. reconstruction; Essex, 5236 Upper Jay-Keene 6.06 mi. bit. mac. resurfacing; Warren, 691, Riverside-Chestertown 4.50 mi., bit. mac. resurfacing.

N. Y., Brooklyn—Following impvts. authorized: Grading Jamaica Bay blvd. from line abt. 1306 ft. so. of Sheridan avenue to northerly end of the U. S. pier bulkhead. Est. cost $30,000; grading & otherwise improving blvd. at a width of 52 ft. across, on areas under lease but not under private agreement for impvt. Est. cost $180,000. preliminary authorization for following local improvements: Regulating & grading Hegeman Ave.,—Hopkinson Ave. to E. 98th St. Est. cost $7,800; paving with granite blk., Maspeth Ave.,—Olive St. to Morgan Ave. Est. $9,000; regulating & grading Carroll St.,—Utica Ave. to Schenectady Ave., $12,-000; grading 81st St.,—17th Ave. to 475 ft. westerly therefrom. Est. cost $2,000; paving with asph. Bay 29th St.—Bath avenue to Corpsey Ave. Est. cost $7,500; paving with asph. W. 25th St.,—Mermaid Ave. to Neptune Ave. Est. cost $11,200.

Ohio, Columbus—State Hwy. Comm., announces that $200,000 will be given by state toward cost of paving and improving 26 miles of state-county roads in Montgomery County during 1920. According to Co. Engr. Bookwalter the financial aid from state will allow Co. Commrs. to carry out their $3,000,000 road bldg. program. Roads to be improved are the Old Troy Pike; New Troy Pike; Covington Pike, Salem Pike, Germantown Pike, etc.

Okla., Shawnee—Resolution presented to Council providing for paving abt. 40 streets within corporate limits. Over 5 miles of the proposed 20 miles will be improved without remonstrance.

Pa., Mt. Carmel—Resolution adopted by Northumberland Co. Commrs. providing that County pay $60,750, or one-half the cost of paving the road betw. Elysburg and Paxinos. State will also pay $60,750.

S. D., Flandreau—City has retained L. P. Wolff, Engr., 1,000 Guardian Life Bldg., St. Paul, to make survey for about 30,000 sq. yds. grading and paving. Will take alt. bids in Spring on: (a) r. c., (b) asph. concrete, (c) bithu., (d) creo. paving.

Tenn., Nashville—Contracts will be let about April 1st for constr. of about 40 miles state hwy.,—Sumner County line to the Kentucky county line (Jackson Highway). Jack Baker of Sumner County, has been retained by County as Chief Engr. Road will cost not to exceed $12,000 a mile.

Tex., Texarkana—Council has approved order for creation of paving district on

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Texas side of town, which will include the greater portion of that side of the city and which will call for expendt. of about $800,000 for street bldg. during present year. In business section brick will be used and in the residence sections, asph. with conc. base.

Vt., Montpelier—Surveys completed by State Engr. H. M. McIntosh for 39 miles of highway, Fed. Aid Project. Est. cost $1,000,000.

Wash., Olympia—Program outlined by Commr. James Allen provides for a total of 48 miles of concrete paving and 107 miles of grading, grubbing and surfacing. Total expendt. of state hwy. funds represented in this year's work comes to $3,547,000, including fed. aid on post roads.

Wn., Walla Walla—Validity of Donahue Road Act upheld by Wash. Supreme Court. This will mean, as soon as proper petitions can be presented to County Commrs., the bldg. of more than 50 miles hard surf. rds. in Walla Walla County. One of the most important roads to be constructed is the 6-mile stretch betw. here and the Oregon-Washington state line which has been delayed pending the Court decision.

W. Va., Clarksburg—Plans prepared for paving various streets, laying storm sewers in Main and Pike streets; also bldg. bridge on Adamston, Pike and Main Sts. Abt. $900,000.

Wis., Beaver Dam—Dodge County voted $5,400,000 hwy. bonds at special election.

Wis., Chilton—Calumet County Bd. has voted $132,000 bonds for highway impvts.; Chilton-Hilbert Rd., 16 ft. conc. or conc. base with approved top and New Holstein-Elkhart Lake Rd. 16 ft. conc. on conc. base with approved top. Wm. Hoenig, Chilton, Co. Aud.

Wis., Dodgeville—Wisc. Hwy. Comn. has notified Co. Bd. Iowa County, that it will grade, drain and surf. with 18-ft. conc. Mineral Point-Dodgeville Rd. Est. cost $204,000. Chas. Wonn, Dodgeville, Co. Hwy. Commr. Co. Board has appropriated $10,000 for purchase of road machy., including patrolmen's graders and other small tools.

Wis., Fond du Lac—Plans completed for paving and cement curb and gutter on Waupum; 45,000 sq. yds. conc. brk. creo. block or asph. conc. Approx. 9 miles of cement curb and gutter. Engr. Parsons & Orbert, Merchants & Mfrs.' Bank Bldg. Milwaukee. H. A. Lockhorst, City Clk.

Wis., Janesville—Common Council adopted paving program for 1920 which includes paving 65 city blocks with brick and asphalt. Work will be started early in Spring.

SEWERAGE AND SEWAGE TREATMENT

Ark., Cotton Plant—City plans constr. of sewer system and drainage.

Ark., Heber Springs—Ord. passed by Council compelling each property owner to connect with city water and sewer systems. Work is to begin in business district and will be completed by blocks.

Cal., Blythe—Olmstead & Gillelen, Consit. Engrs., Hollingsworth Bldg., Los Angeles, retained by city to prepare plans and estimates for sewer system for town.

Cal., Burbank—Koebig & Koebig, 841 Title Ins. Bldg., retained by city to prepare plans and estimates for sewer system prelim. to submitting bond issue. Est. cost from $100,000 to $150,000.

Cal., Calipatria—$40,000 bonds voted to construct sewerage system. E. M. Lynch, Central Bldg., Los Angeles, Engr.

Cal., El Monte—$55,000 bonds voted for purpose of bldg. sewerage system and septic tank. Olmstead & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, Engineers.

NOTICE TO CONTRACTORS.

Livingston, Montana.

Sealed bids and proposals will be received at the office of the undersigned, in the City of Livingston, County of Park, State of Montana, until five (5) o'clock P. M., on the 1st day of March, A. D., 1920 for the construction of paving and appurtenances in the City of Livingston, Montana.

Instructions to Bidders, Plans and Specifications, and Blank Forms of proposal can be obtained upon application at the office of C. T. Sacket, City Engineer, on the payment of Ten (10) Dollars.

There will be approximately thirty-eight thousand ninety-eight (38.098) cubic yards of excavation, one hundred seventy thousand five hundred thirty-three (170,533) square yards of paving, twelve hundred eighty-two (1,282) lineal feet of corrugated gutter pipe and twelve thousand three hundred fifty-six (12,356) lineal feet of attached curb. Bids will be received upon any or all of the following types of paving:

Vitrified brick; wood block; concrete, plain or reinforced; asphaltic concrete (Topeka Mix) on cement base or crushed rock base; Warrenite-Bitulithic on bases of cement concrete, bituminous concrete or compressed broken stone.

The right to reject any and all bids is reserved by the City Council of the City of Livingston, Montana.

Dated this 17th day of January, 1920.

Livingston, Montana.
Harry M. Shelver,
City Clerk.

NOTICE TO CONTRACTORS.

Livingston, Montana.

Sealed bids and proposals will be received at the office of the undersigned, in the City of Livingston, County of Park, State of Montana, until five (5) o'clock P. M. on the 1st day of March A. D. 1920, for the construction of storm sewers in Special Improvement District No-89 in the City of Livingston, Montana.

Instructions to Bidders Plans, Specifications and Blank Forms of Proposal can be obtained upon application at the office of C. T. Sacket, City Engineer, on the payment of five (5) Dollars.

There will be approximately eleven hundred (1,100) lineal feet of twelve (12) inch sewer pipe; seventy-seven hundred (7,700) lineal feet of ten (10) inch sewer pipe; eighteen hundred (1,800) lineal feet of eight (8) inch sewer pipe; twenty (20) concrete manholes and sixty (60) inlets with catch basins.

The right to reject any and all bids is reserved by the City Council of the City of Livingston, Montana.

Dated this 17th day of January 1920.

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